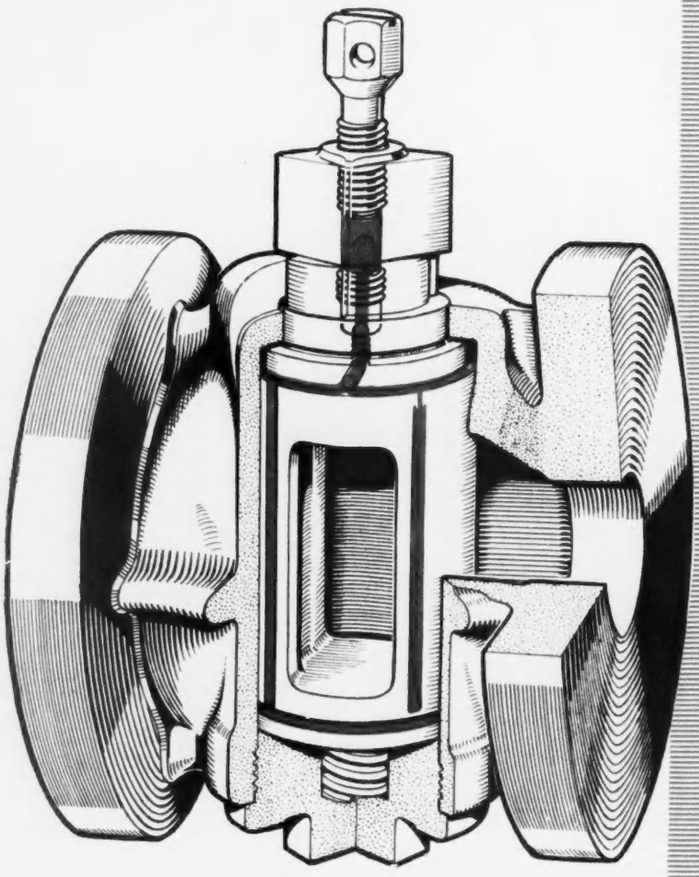
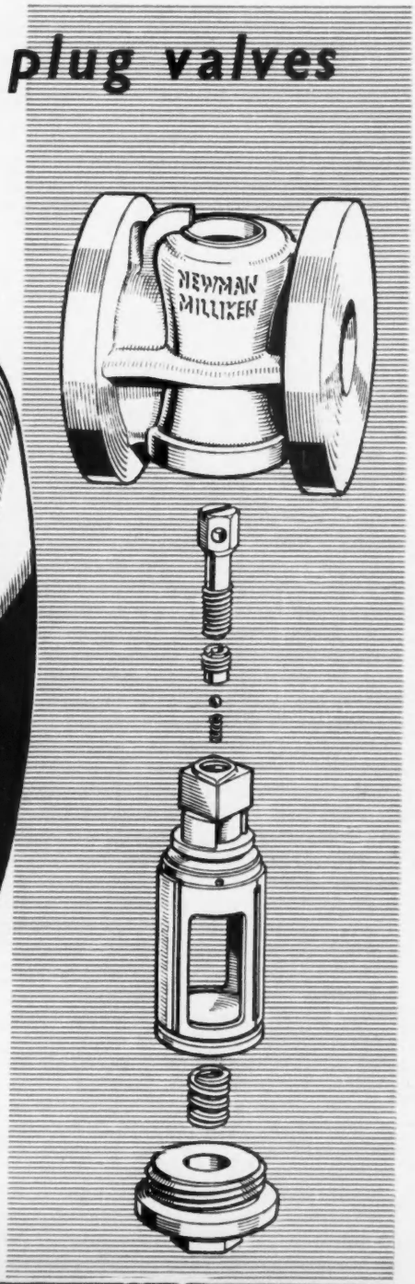
The Engineer

SEPTEMBER 12, 1958 28 ESSEX ST., STRAND, LONDON, W.C.2 TWO SHILLINGS

Newman-Milliken

Glandless lubricated plug valves





- The Newman-Milliken is a glandless, lubricated, parallel plug Stop Valve, of full bore.
- The parallel plug reduces wear to a minimum and greatly facilitates maintenance.
- The plug can be dropped out of the body and the valve can be serviced without removal from the pipe line.
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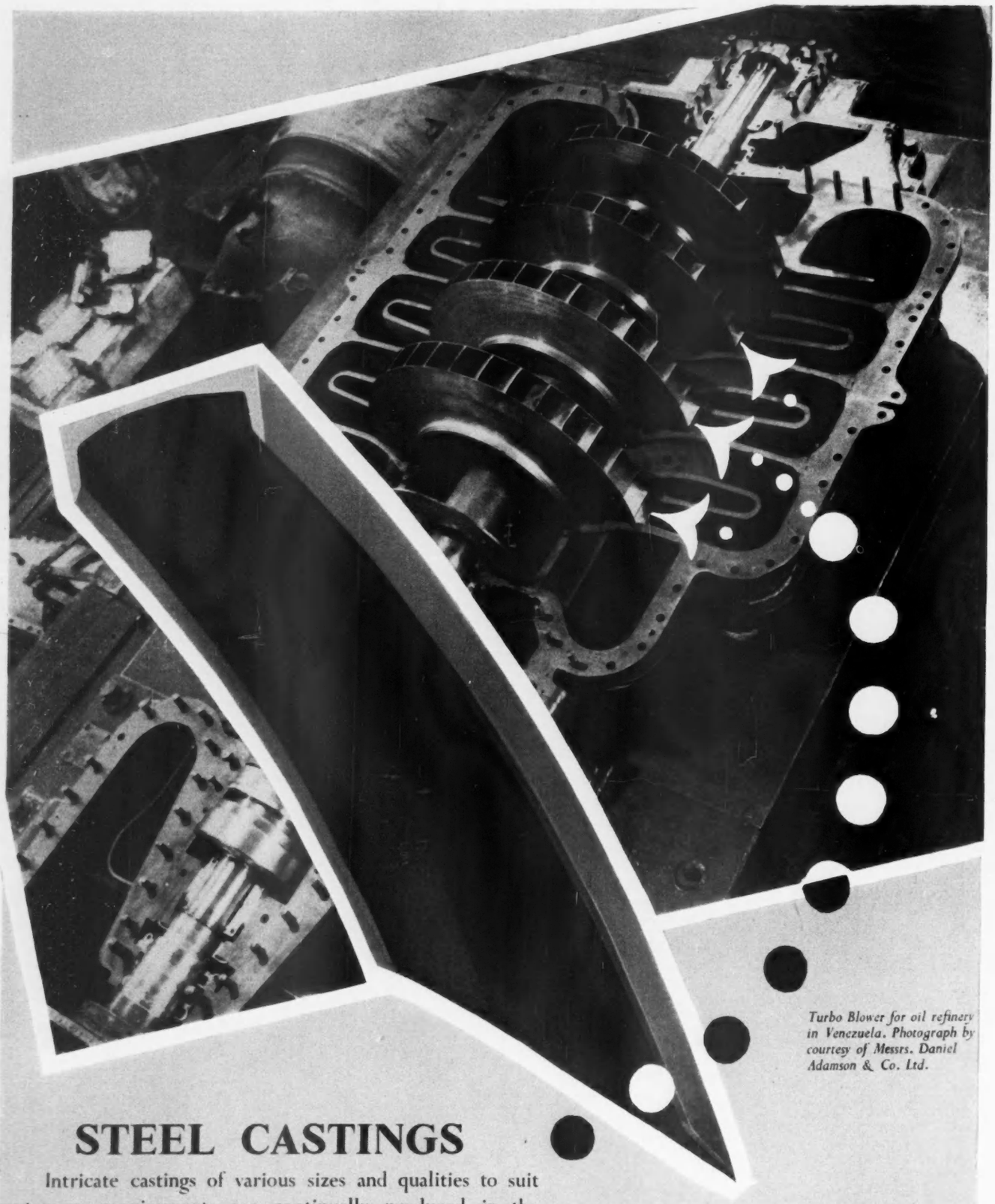

Turbo Blower for oil refinery in Venezuela. Photograph by courtesy of Messrs. Daniel Adamson & Co. Ltd.

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THE ENGINEER

Established 1856

No. 5355 **SEPTEMBER 12, 1958** VOL. 206

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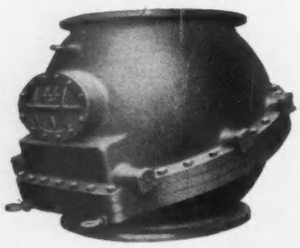

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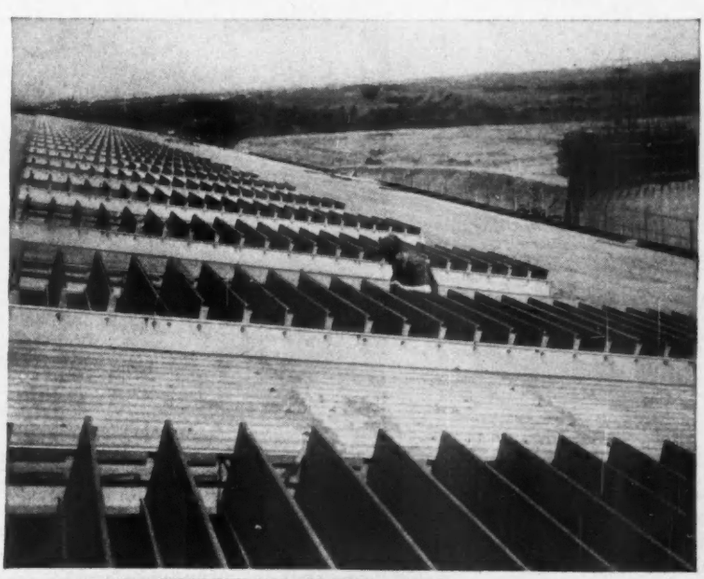

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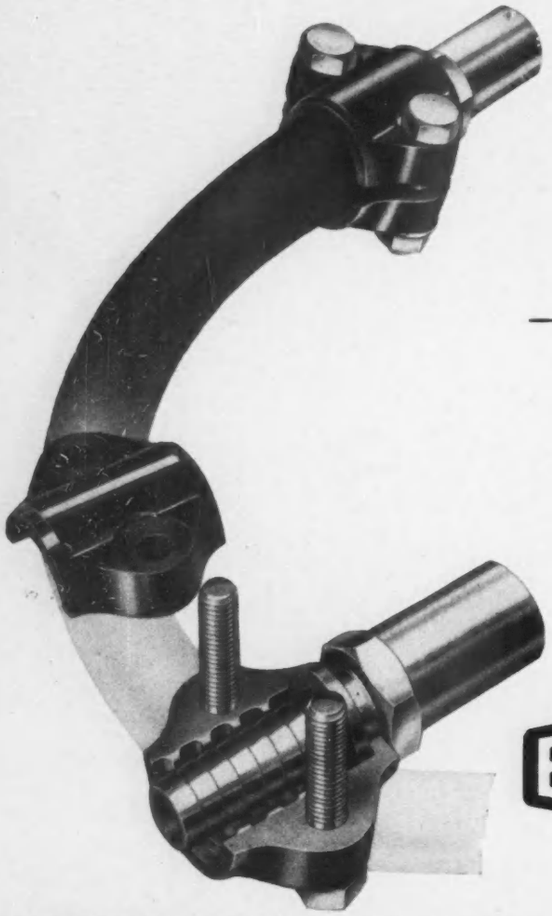

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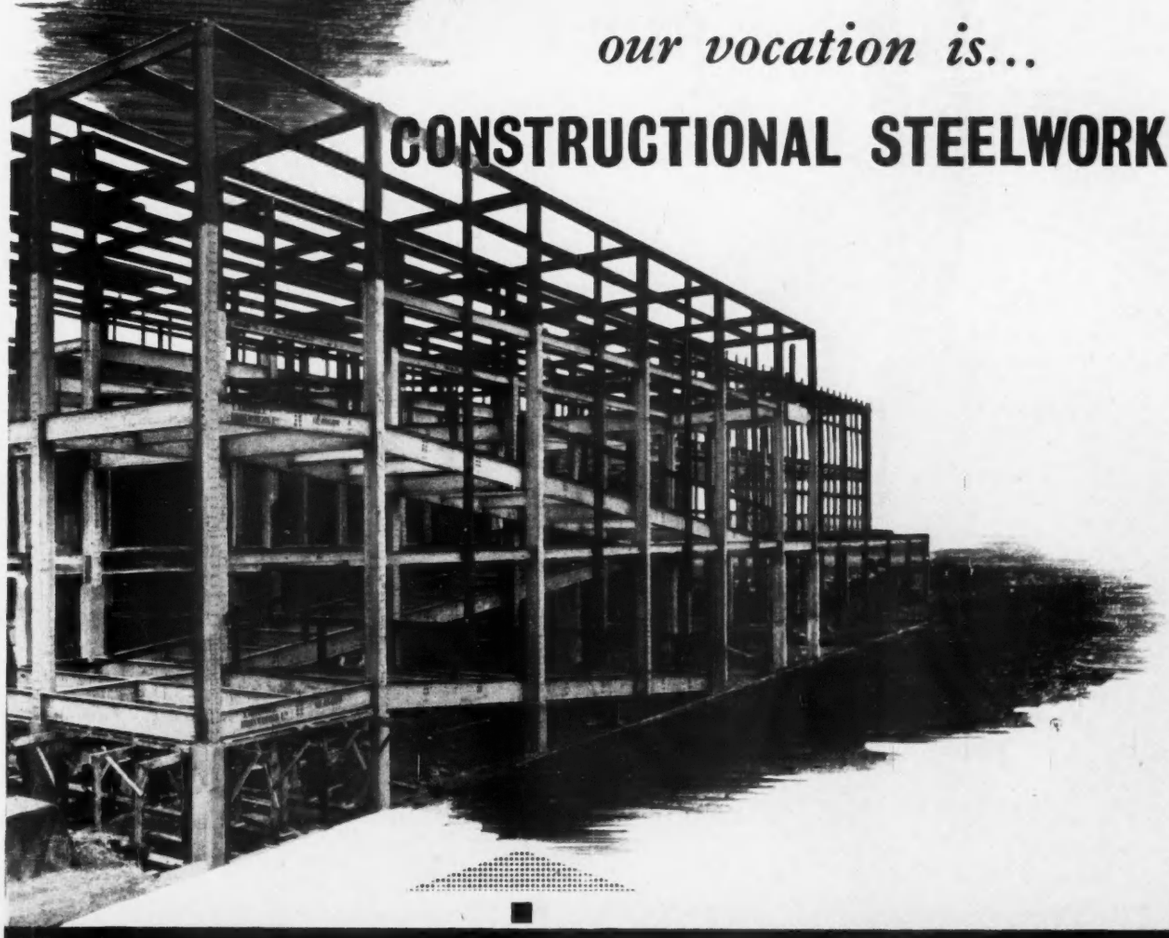

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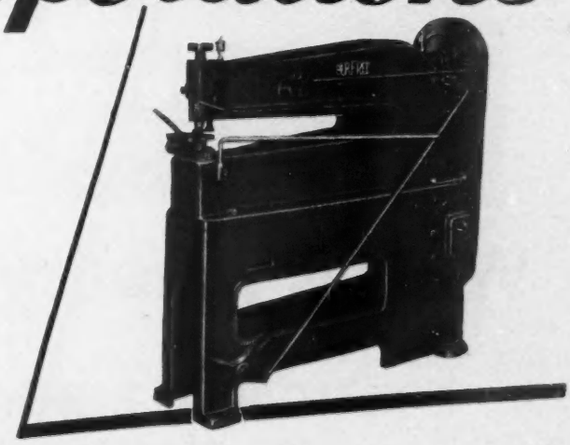

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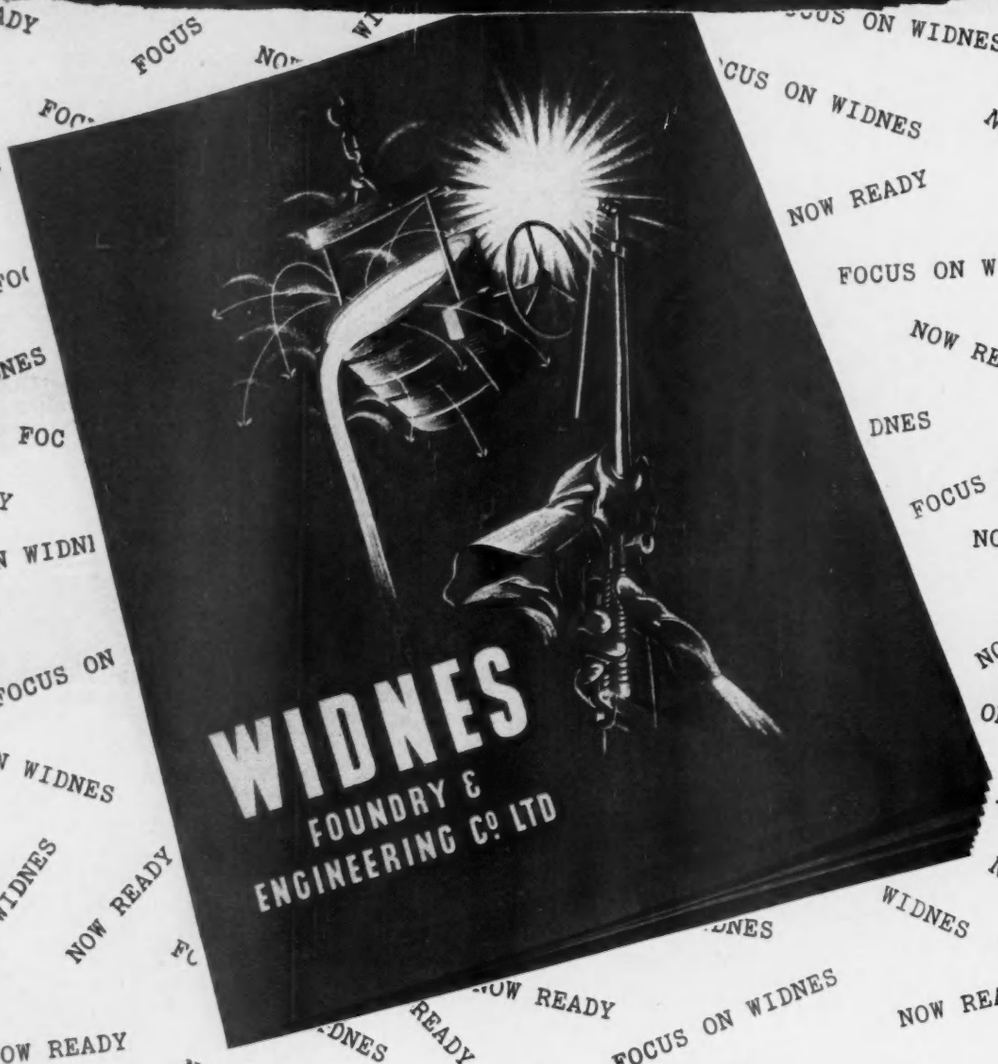

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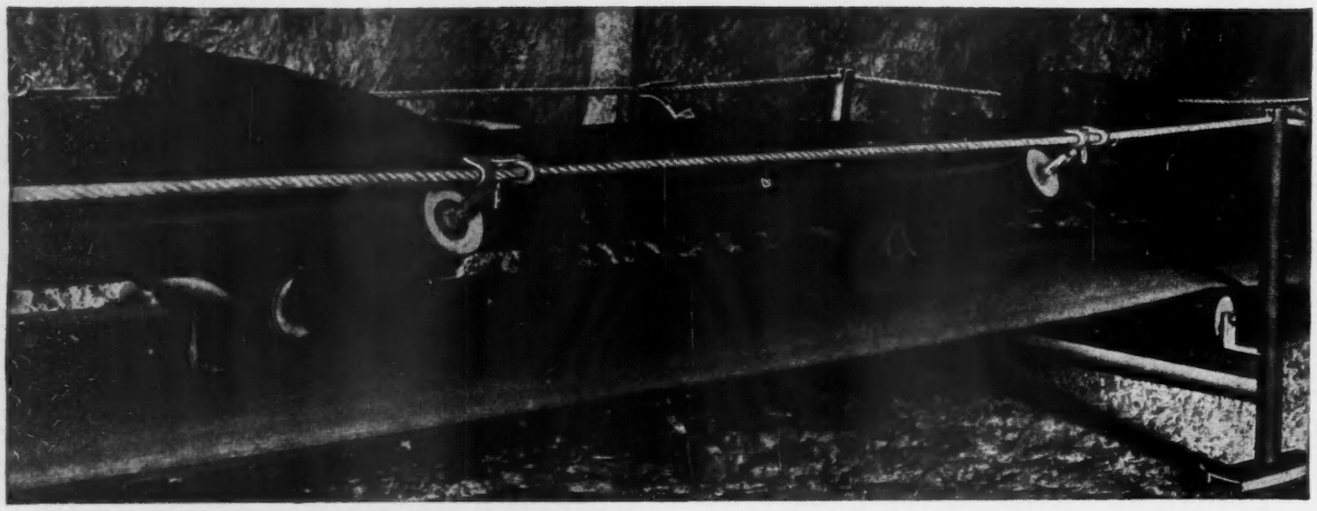

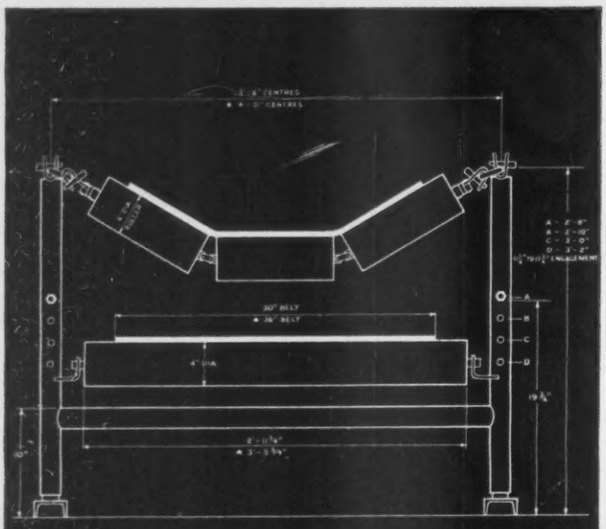

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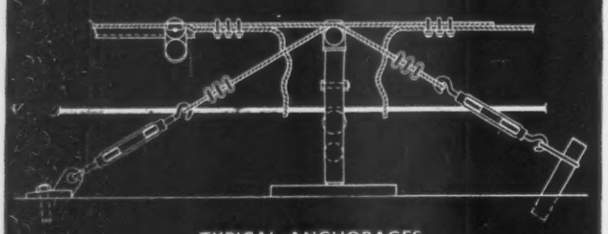

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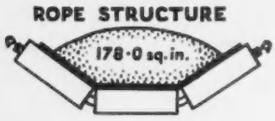

Greater conveying capacity obtainable by increased troughing under load

The longitudinal members of this conveyor structure consist of $\frac{5}{8}$" dia. steel ropes in tension. The connections at the ends of each troughing idler shaft are hinged. These basic features provide a resilient conveyor which is easy to stack, transport and install — a conveyor in which impact damage to the belt as it passes over the idlers is greatly reduced. The belt is easy to train. The bottom belt is in full view and there need not be any concealed rubbing between belt and structure.

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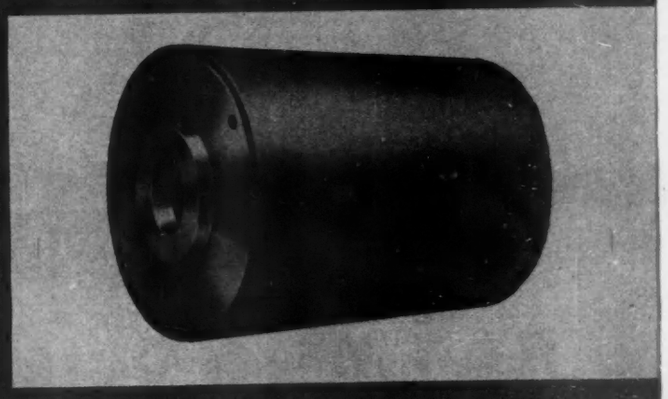

The sealing drum of this polythene bag-making machine, used by Paper Goods Manufacturing Co. Ltd., has a coating of I.C.I. Silicone Rubber fabricated by The Dunlop Rubber Company.

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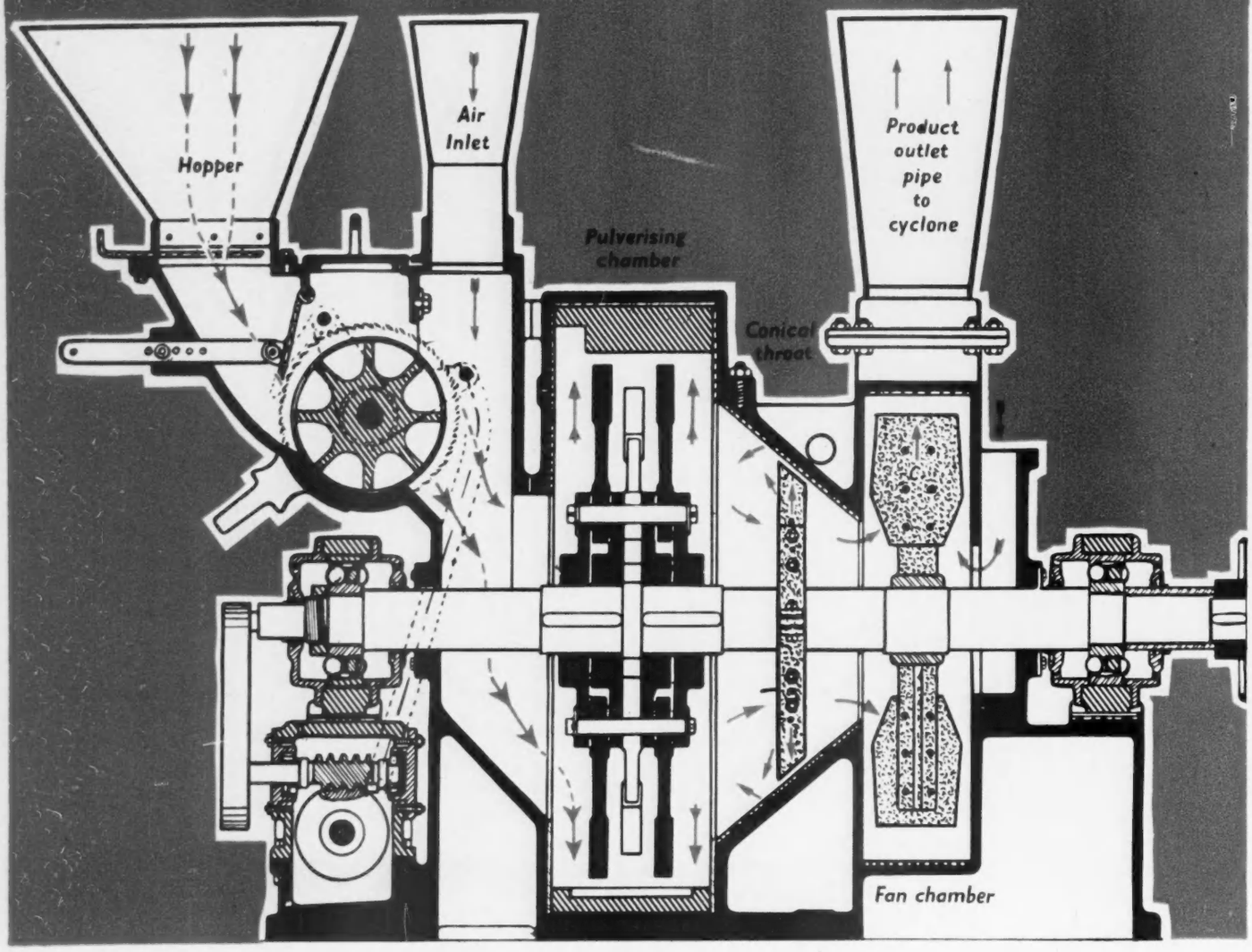

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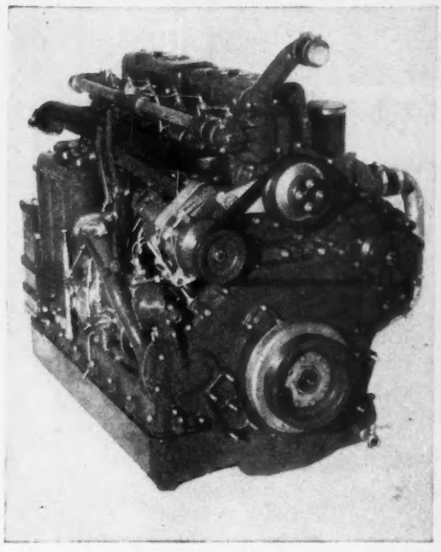

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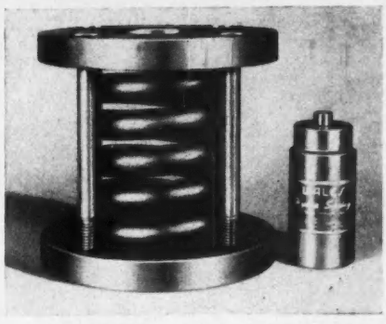

. . . in liquid springs

A steel coil spring and a liquid spring of equivalent performance are shown. The liquid spring contains a silicone fluid which is highly compressible, will show little change in viscosity over a wide temperature range and will not break down even at high temperatures.

You are invited to write for full information about the properties and applications of silicone fluids. Literature on the many other MS silicone products including rubbers, resins, lubricants, compounds, electrical insulants, release and antifoam agents, is also available on request.

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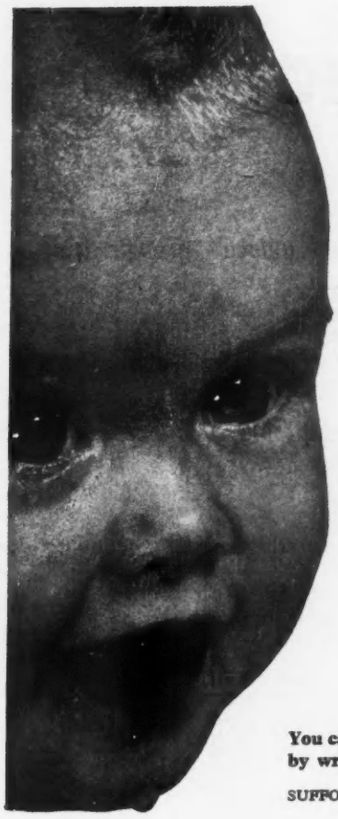

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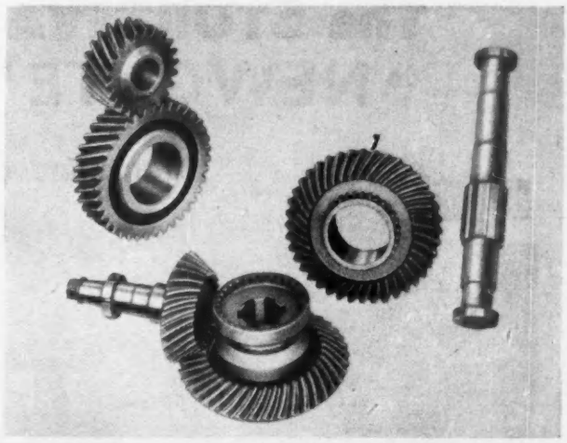

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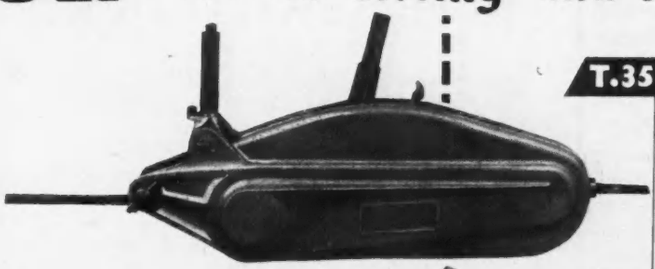
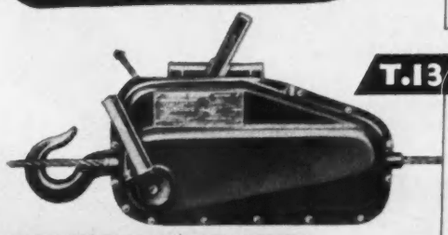


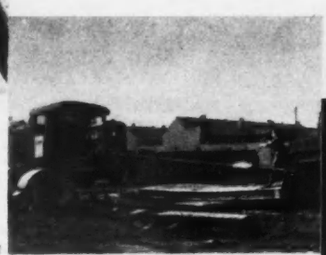
T.35

CAPACITY	LIFTING (SWL) 3 TONS PULLING 5 TONS
EFFORT	70/120 LBS.
WEIGHT	59 LBS.
SPEED	3/9 FT. PER MIN
SIZE	28¼" x 12½" x 5½"
MECH. ADV.	85 : 1



T.13

CAPACITY	LIFTING (SWL) 1 TON PULLING 30 CWT.
EFFORT	77 LBS.
WEIGHT	39 LBS.
SPEED	11½ FT. PER MIN
SIZE	24" x 12" x 6"
MECH. ADV.	43 : 1



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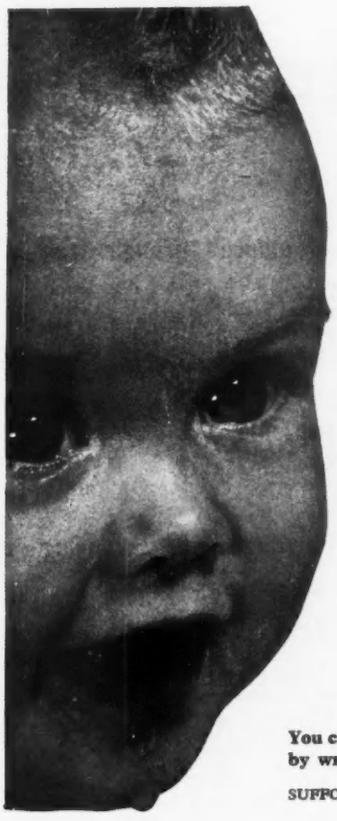

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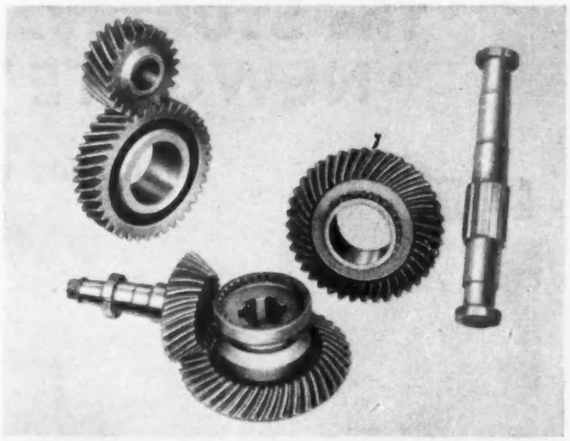

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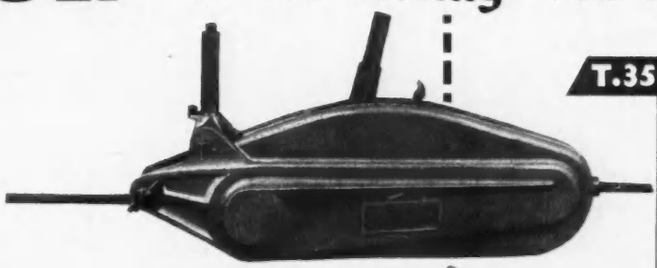

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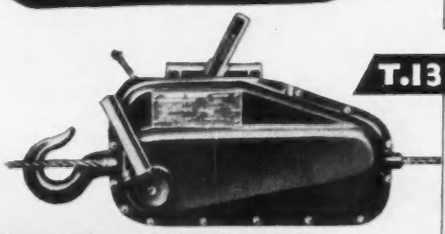

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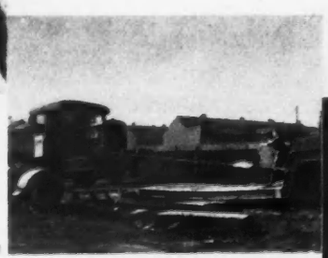

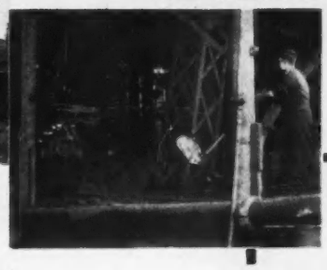

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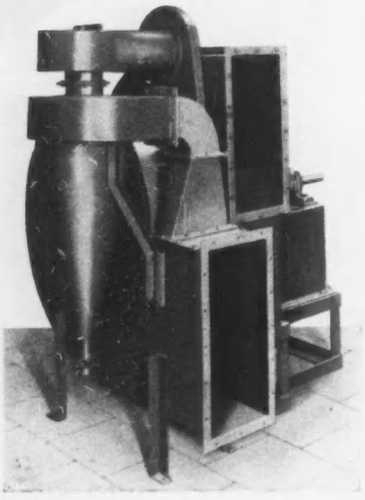

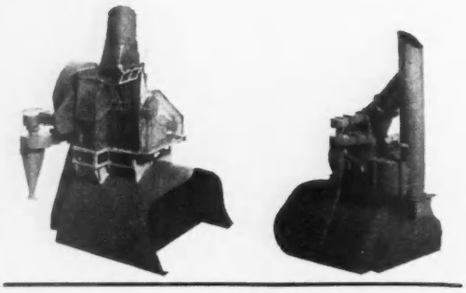

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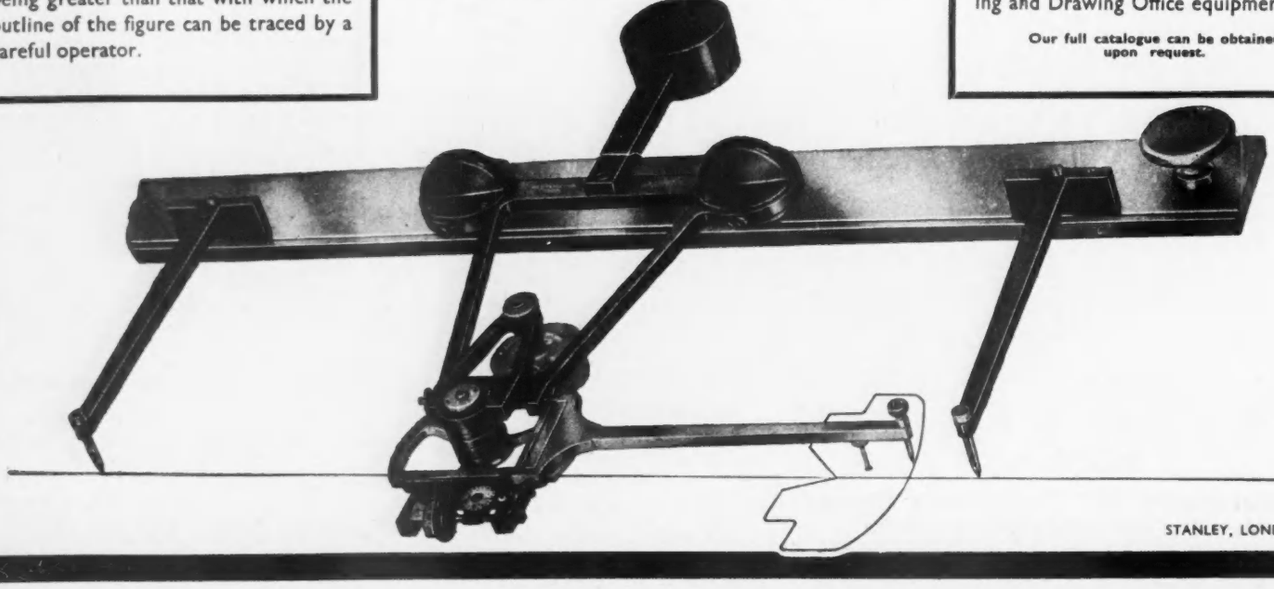

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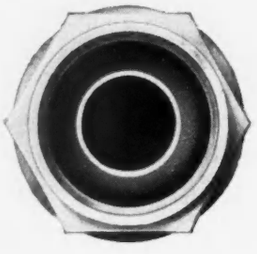

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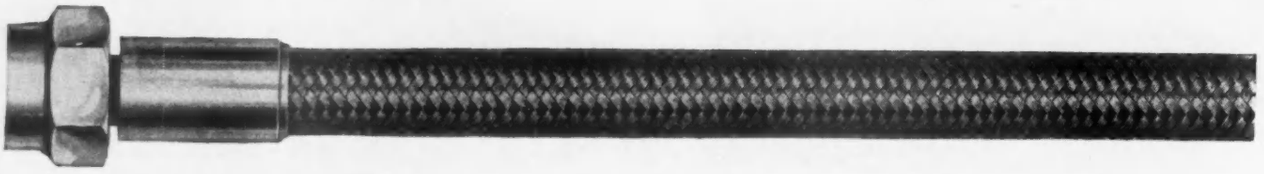

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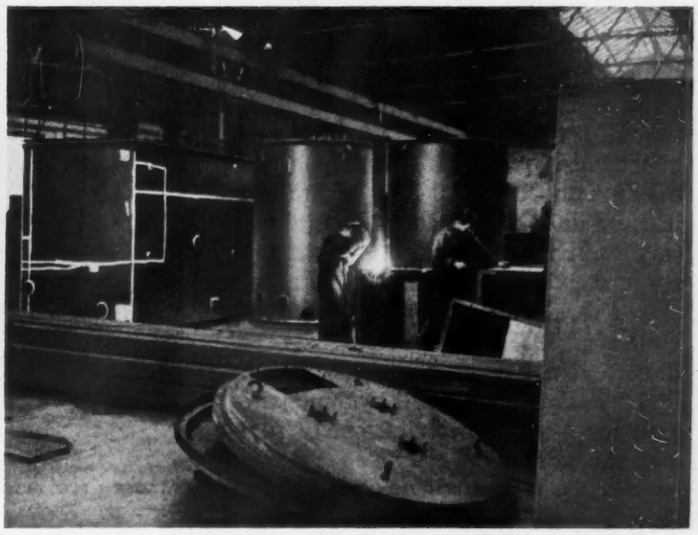

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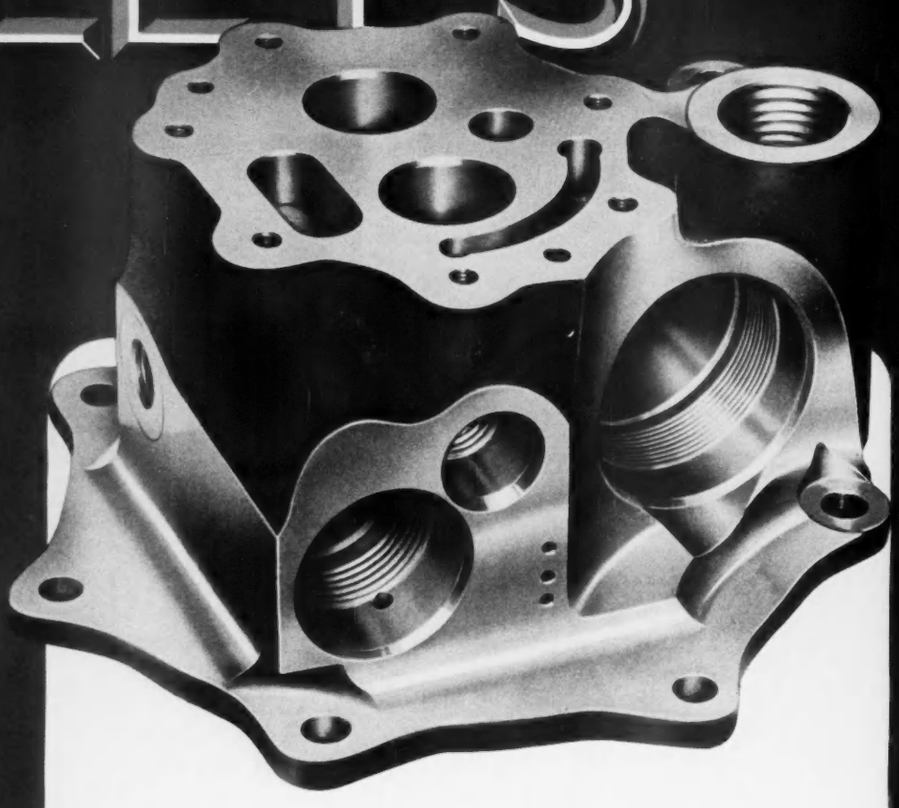

The illustration shows a valve body for use in hydraulic control equipment. The complex nature of this valve body involves a great deal of machining; at the same time high mechanical strength is an important factor, since the valves are used at a high working pressure and are tested at 2,500 p.s.i.

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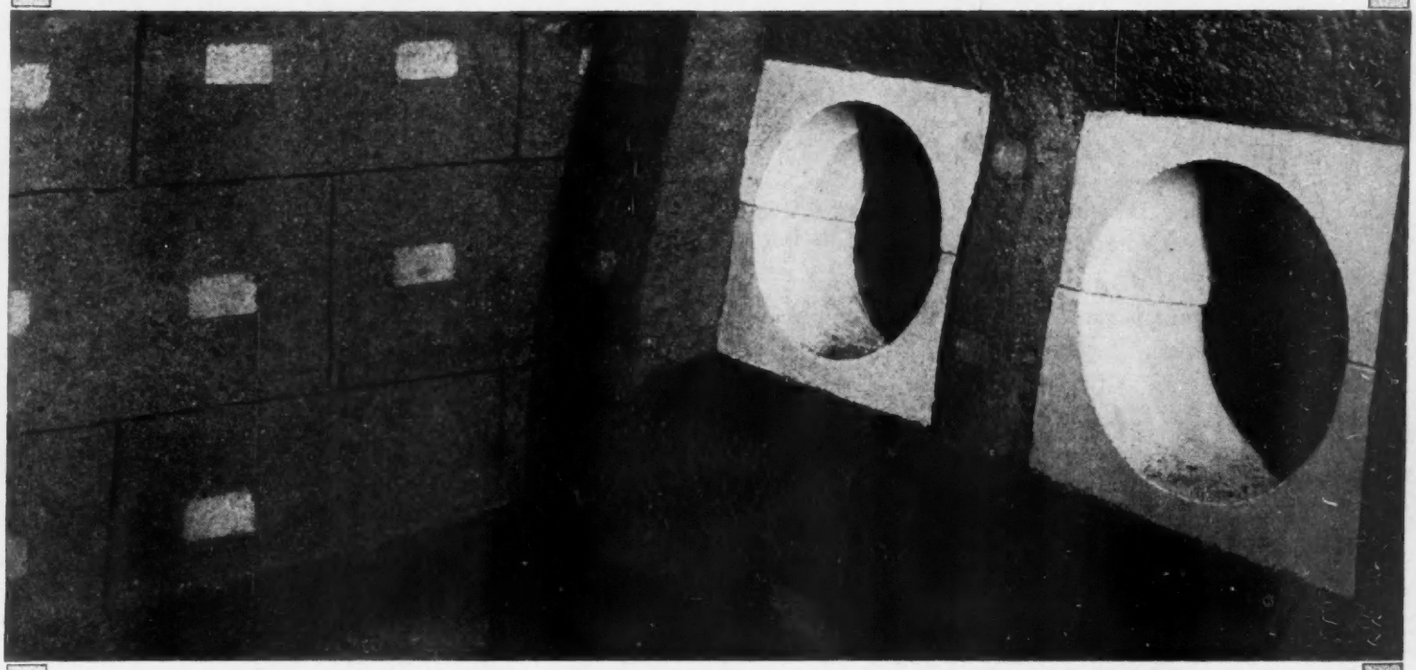

Front and side walls of a Queen Mary boiler in Tri-Mor High Temperature Mouldable, with MR 60 anchors. Burner quarls in Tri-Mor High Temperature Castable.

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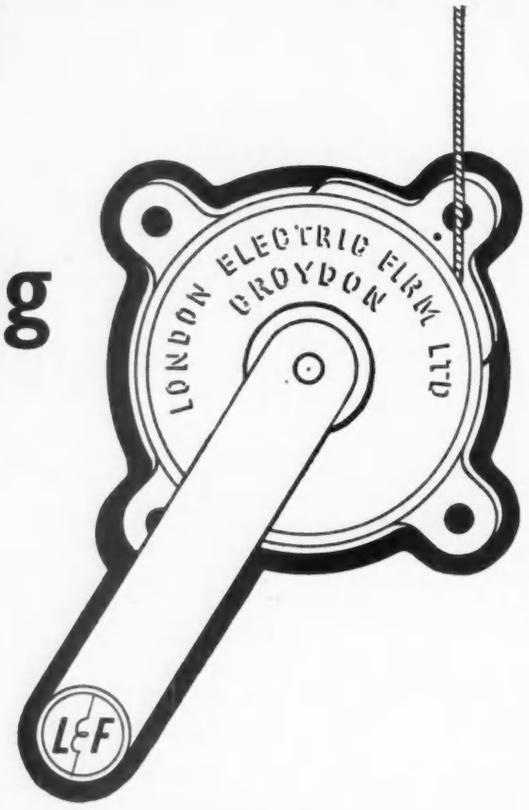

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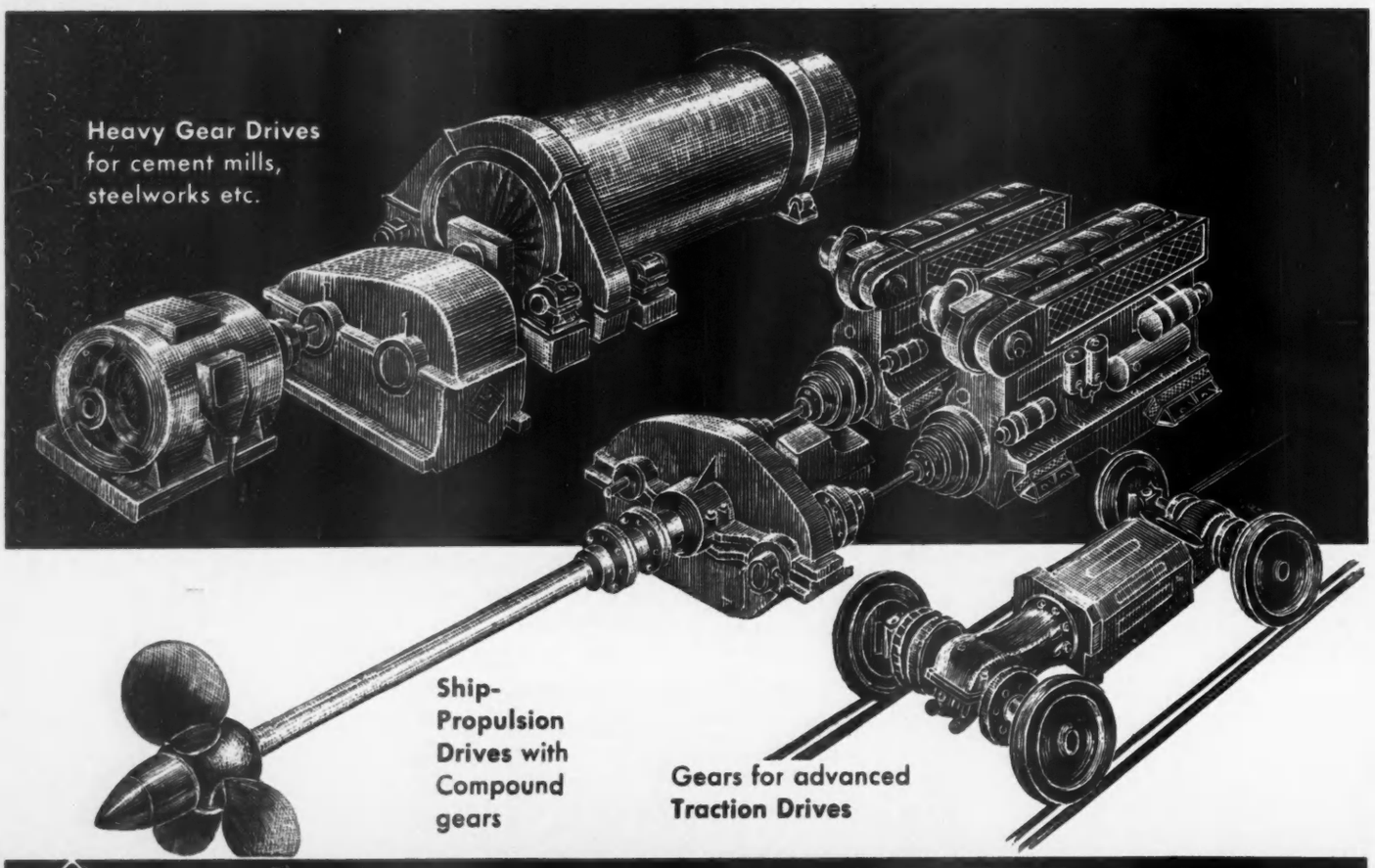

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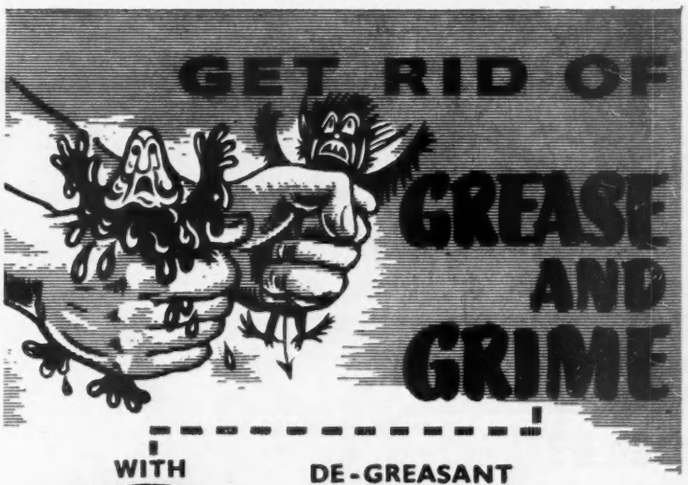

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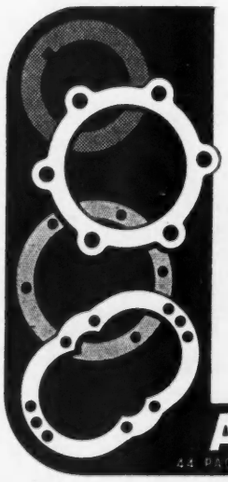

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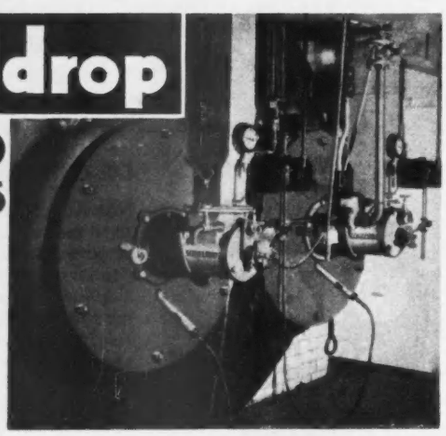
OIL FIRED BOILERS

We Guarantee

13½ to 14 per cent CO_2 with Shell Smoke number 4 or less.



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STOTFOLD, BEDS. Tel. 414 (3 lines) OFFICES AT : BIRMINGHAM · LONDON · MANCHESTER SWANSEA · GLASGOW.

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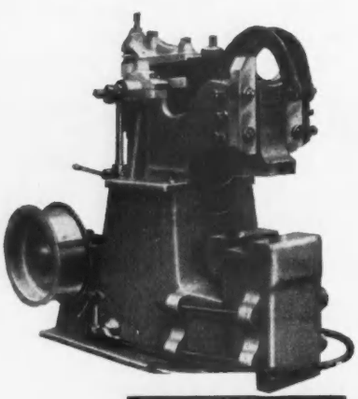

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TO YOUR ELBOW !

- 275/300 blows per minute.
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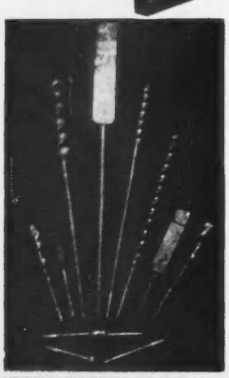
- Separate motor stand available.



A typical example of the type of work accomplished on this machine.

For High Speed Precision Forging— the Model '100' POWER HAMMER.

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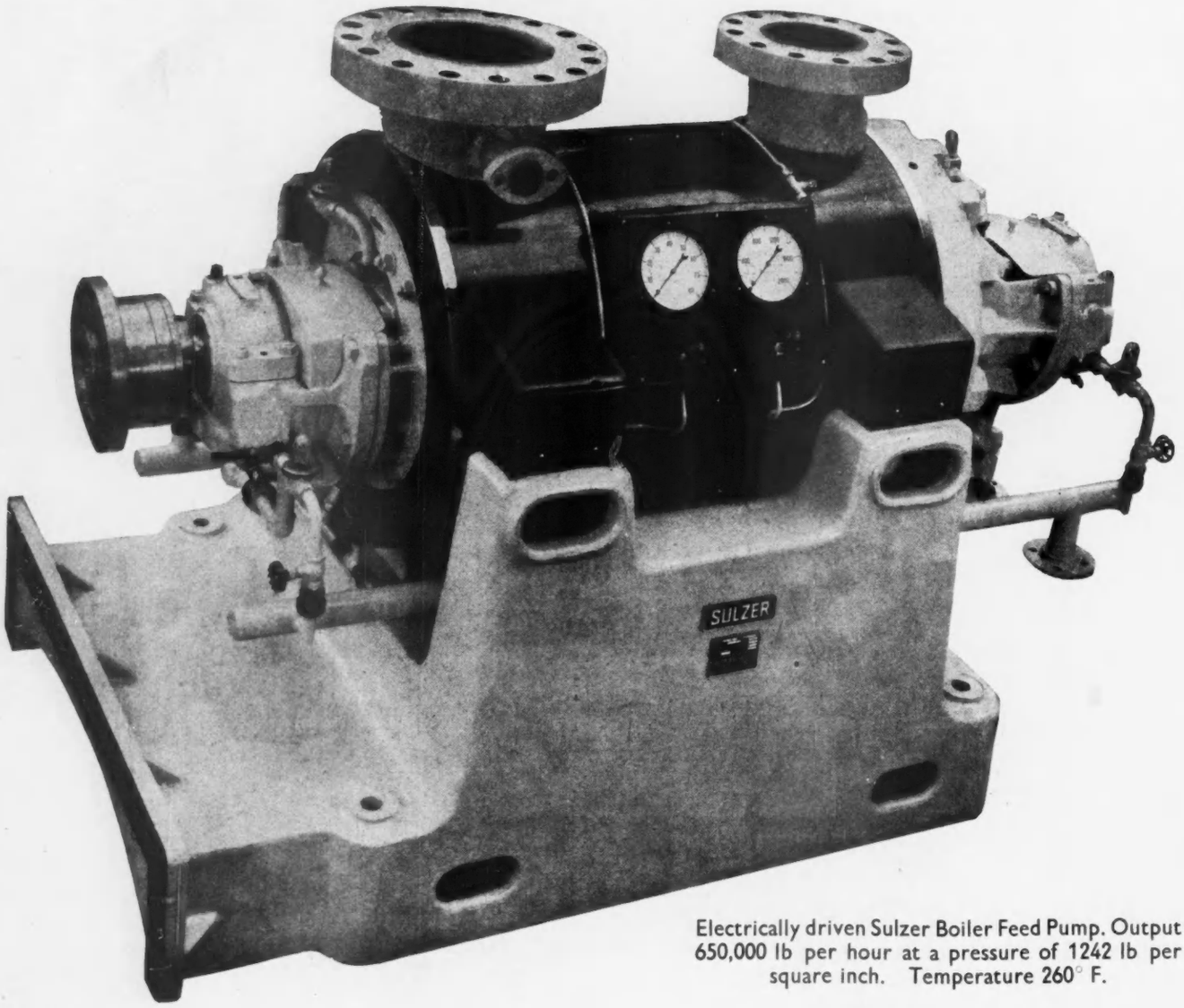
AP 79

SULZER

BOILER-FEED PUMPS



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One of nine units for
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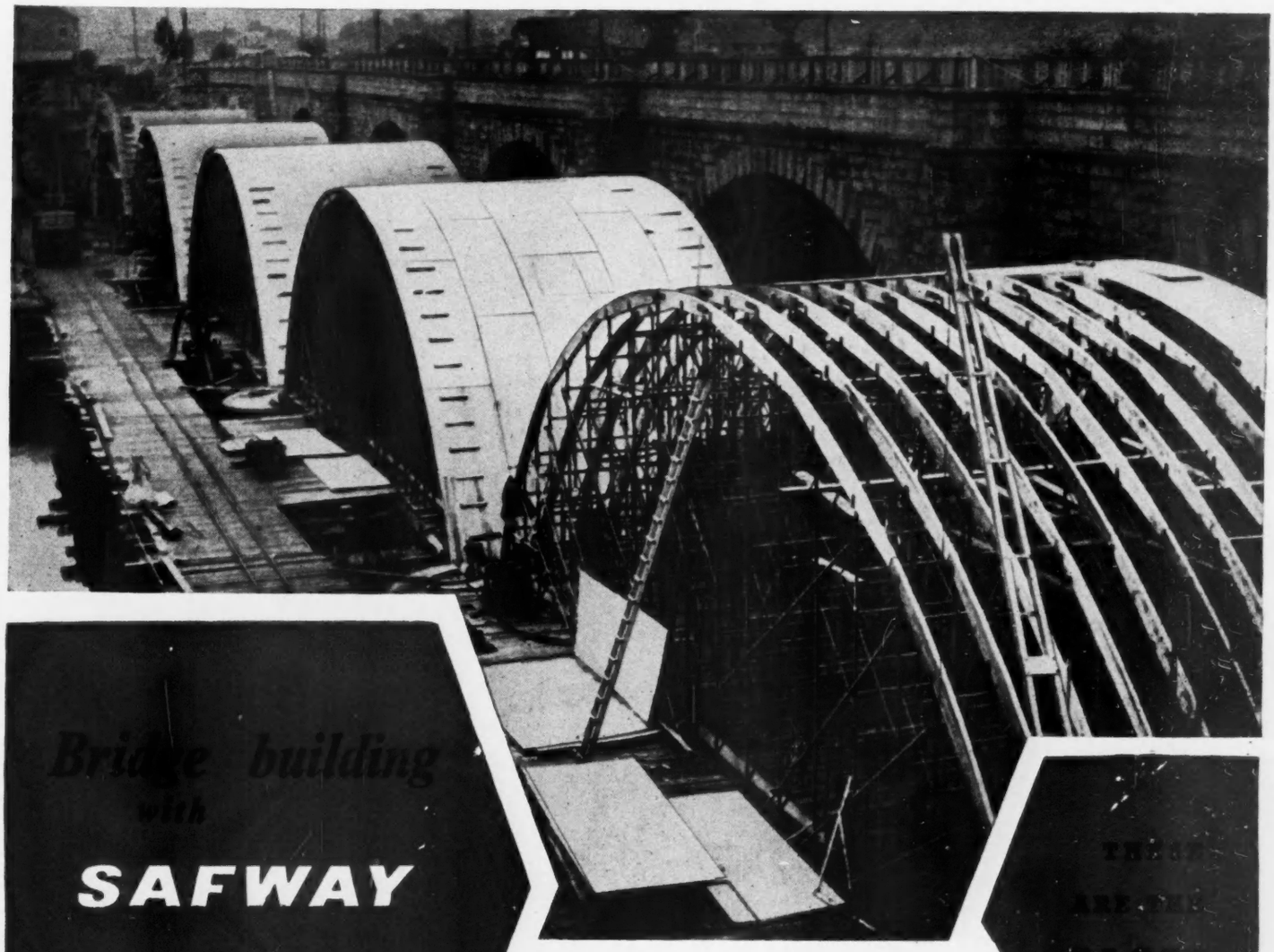

Bridge building with SAFWAY

1 The whole of the scaffolding supporting the shuttering for this bridge erected in 1,100 man hours.

2 Labour force of only five men on scaffolding (3 of which were unskilled).

3 Only Safway equipment used throughout.

4 Size of each arch 75 ft. x 25 ft. 6 ins. x 28 ft. 6 in. wide. Total load per arch 215 tons.

5 Minute adjustment of scaffolding to follow arch curve achieved with Adjustable screws in base and head.

6 Joiners work reduced to a minimum.

Contractors : H. M. Murray & Co. Ltd., Glasgow and Inverness.

Photo by courtesy of the City Engineer, Aberdeen — A. G. Booth, M.E., A.M.I.C.E.

SAFWAY unit frame

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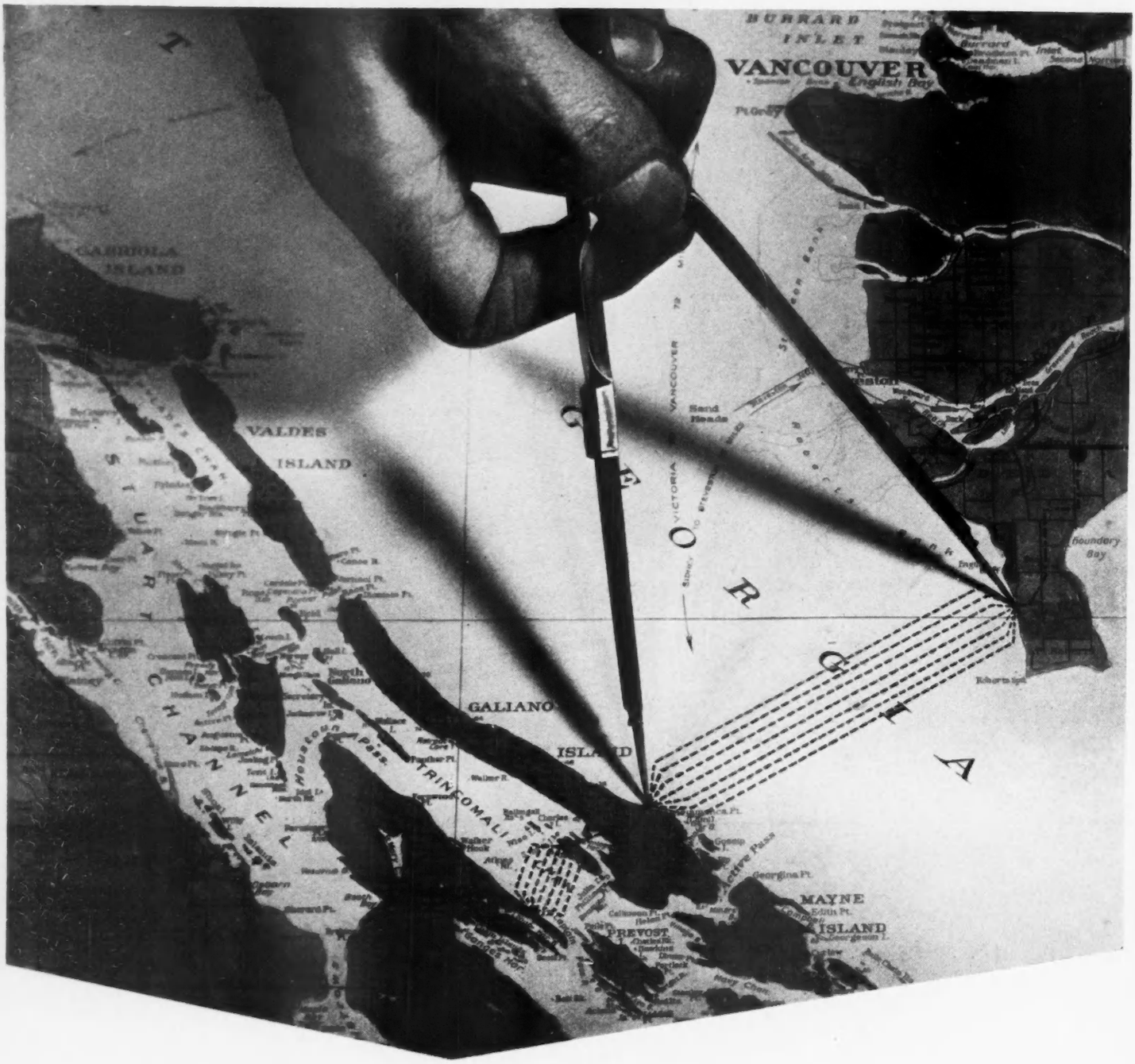
Cogent



Yet another great power cable achievement!

A second circuit completed in the submarine power link between the British Columbia mainland and Vancouver Island

In September 1956 the first submarine power circuit between the British Columbia mainland and Vancouver Island was put into commission. It had been designed, made and laid by the BICC Group to transmit some 170,000 H.P. of hydro-electric power across the Georgia Strait and Trincomali Channel.

The link proved so outstandingly successful that a year after its commission, almost to the day, the British Columbia Electric Company awarded BICC another contract to supply a second circuit. This is now in service — after less than twelve months!

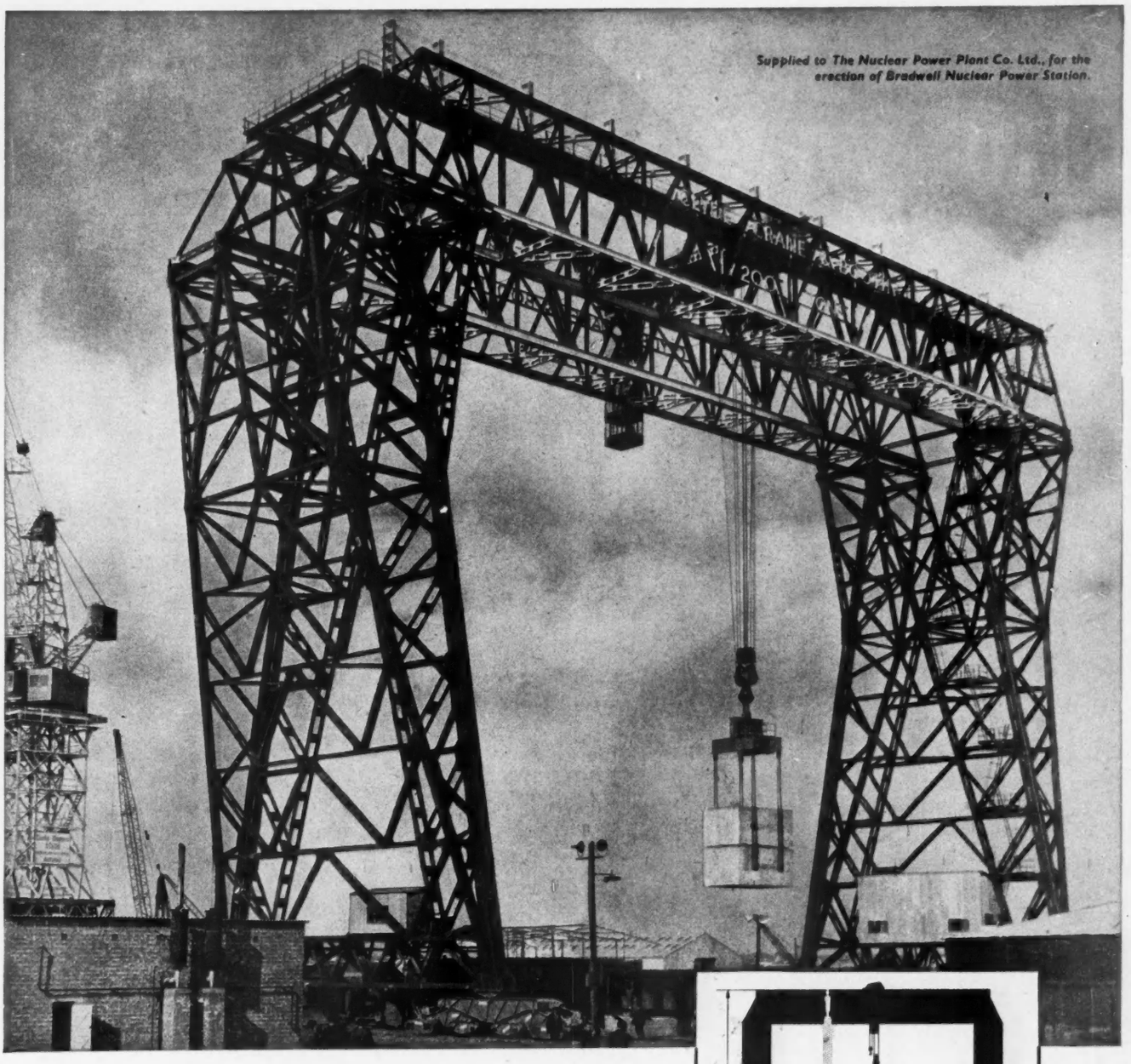
Altogether more than 133 miles of 138kV single core cable, including seven 16-mile continuous lengths,* have been made and laid by the BICC Group for this great power link, which now transmits 335,000 H.P.

**These cables are unique : they are the longest ever made for operation at such a voltage.*

by the **BICC GROUP**

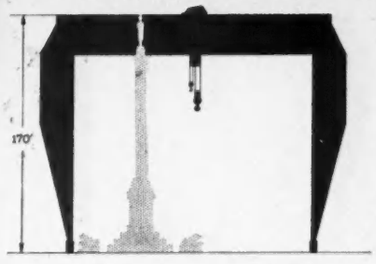
BRITISH INSULATED CALLENDER'S CABLES LIMITED, 21, BLOOMSBURY STREET, LONDON W.C.1

CLYDE-BOOTH 200 TONS GOLIATH AT *BRADWELL NUCLEAR POWER STATION*



Supplied to The Nuclear Power Plant Co. Ltd., for the erection of Bradwell Nuclear Power Station.

Specially designed for the erection of Bradwell Nuclear Power Station this 200/30 tons Goliath crane handles all the major lifting operations on the main part of the plant. It completely spans the reactor buildings site travelling on rail tracks on either side so that large items of equipment such as boiler shells which weigh up to the crane's full capacity are easily lifted and placed with precision in the position required.



The Booth Goliath showing Nelsons Column on the same scale. Clearance from rail level to underside of bridge is 140'. Distance between rail centres 178'.

CLYDE BOOTH

CLYDE CRANE & BOOTH LIMITED
incorporating

Clyde Crane & Engineering Co.,
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Phone: Holytown 412 (6 lines) Grams: 'Clyde' Motherwell

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E

This was the shape of

oil after radiation

Here was a problem of national importance. Lubricants were needed by the nuclear industry for reactor equipment, much of it subjected to radiation. Yet, like human beings, oils and greases were vulnerable to radiation. Oils darkened in colour and became coarse-grained solids (solidification being but one of a tangled skein of problems).

The Shell Group started working on the problems of lubricating under radiation conditions while most nuclear power stations were still on the drawing board. In fact, Shell was the first oil company to develop Atomic Power Lubricants, and the research that went into Shell A.P.L. is characteristic of the way Shell sets about doing things. A team of research workers was assembled at Shell's Research Centre at Thornton. Series of tests were carried out both in the B.E.P.O. pile at the U.K. Atomic Energy Authority Research Establishment, Harwell, and with Thornton's own Cobalt 60 source of radiation. In 1957, after four years of research, Britain's first range of Atomic Power Lubricants was on the market.

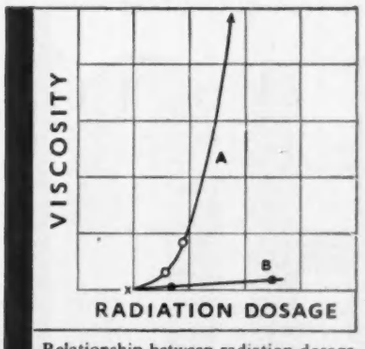
The moral of the A.P.L. story is that Shell research is supremely applicational. The Centre at Thornton is always ready to work with even the most specialised sectors of industry to produce the right oil for the job. If you and your organisation have any major lubrication problems, it will pay you to get in touch with your local distributor of Shell Industrial Lubricants.

The Research Story

In the hundreds of complex hydrocarbons examined, very different reactions to radiation were observed according to the configuration of the atoms in the molecules. When carbon atoms were arranged in long, straight chains, radiation caused these chains to link up with one another, giving highly complex structures of an entirely different nature from the original material. The first effect of this change was to cause a rapid increase in viscosity, ultimately giving rise to a solid rubber-like product.

For example, a high quality turbine oil conforming to BSS.489 receiving a dosage of 1.77×10^{18} neutrons/cm² was changed into an intractable solid—a clear proof that radically new lubricants were needed by the nuclear industry.

Shell Atomic Power Lubricants have a molecular structure that has proved itself very resistant to radiation. In fact it will withstand a radiation dosage four million times stronger than that which will kill a man—without any significant change in structure or physical properties.



Relationship between radiation dosage and percentage increase in viscosity, cS at 100°F.
Oil A: high molecular weight long chain hydrocarbon. *Oil B:* Shell A.P.L. 731.

SHELL

ATOMIC POWER LUBRICANTS

another proof of Shell leadership in Lubrication

Get down to the brass tacks of COMPUTERS

Ordering a computer is relatively easy. Choosing the right one, understanding its use, harnessing it to specific problems, is quite another matter. It is a long process. It needs much probing into the fundamental organisation of your business. Only people who are both computer men and business experts can help you. These are at your service at the Hollerith Computer Centre.

At 36 Hertford Street the Hollerith Computer Centre provides a convenient forum, round a working computer, for the interchange of ideas and results. There are several ways of making good use of the Centre.

Here are two examples:

Higher Management Courses—which provide a concise appreciation of computers in business, with maximum emphasis on case studies of computer usage. These courses last 4 days.

Study Teams from individual organisations come to discuss their own specific problems with our computer experts—production control for example. These courses last from 1 to 5 days.

If you want to see how a computer could solve your particular problem, come and make use of us, come and pick our brains.

at the

HOLLERITH COMPUTER CENTRE

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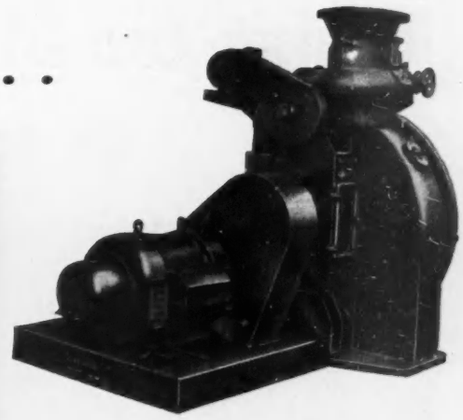
* *Enquiries about the Hollerith Computer Centre can be addressed to any of the district or local offices of* The British Tabulating Machine Company Limited, *or to Head Office:* 17 Park Lane, London, W.1

ATRITOR *DRYER-PULVERISER . . .*



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High efficiency with low grade fuels.

Extremely flexible, will handle a wide range of coals.

. . . for the pulverised-coal firing of boilers

Particularly suitable for the firing of Lancashire, Economic and Water-tube Boilers.

Ability to follow highly fluctuating loads with rapid get-up from cold.

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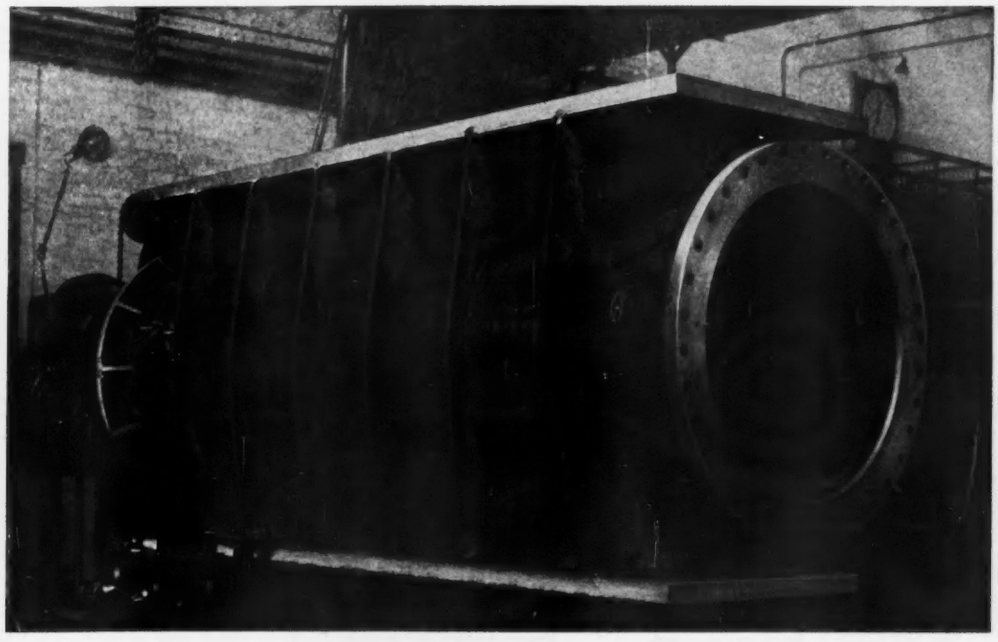

The illustration shows a mild steel vessel, 2′ 8″ internal diameter by 10′ 6¾″ long, fabricated from welded steel plate, approaching completion.
This is for use by B.P. Refinery (Llandarcy) Ltd.

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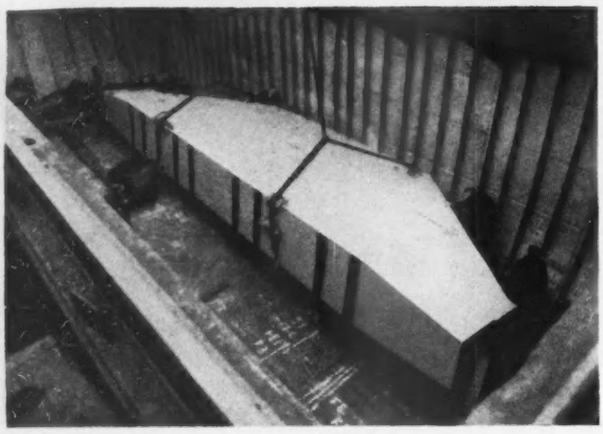

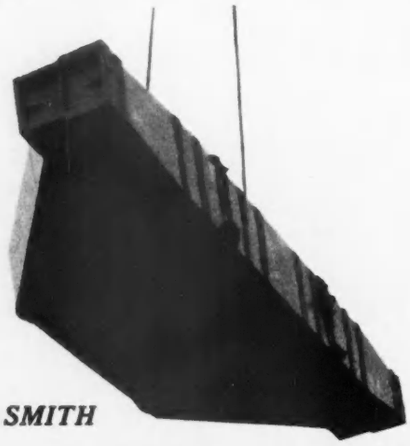

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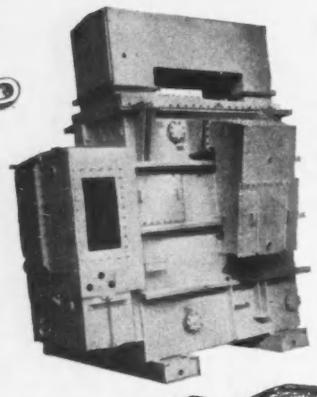

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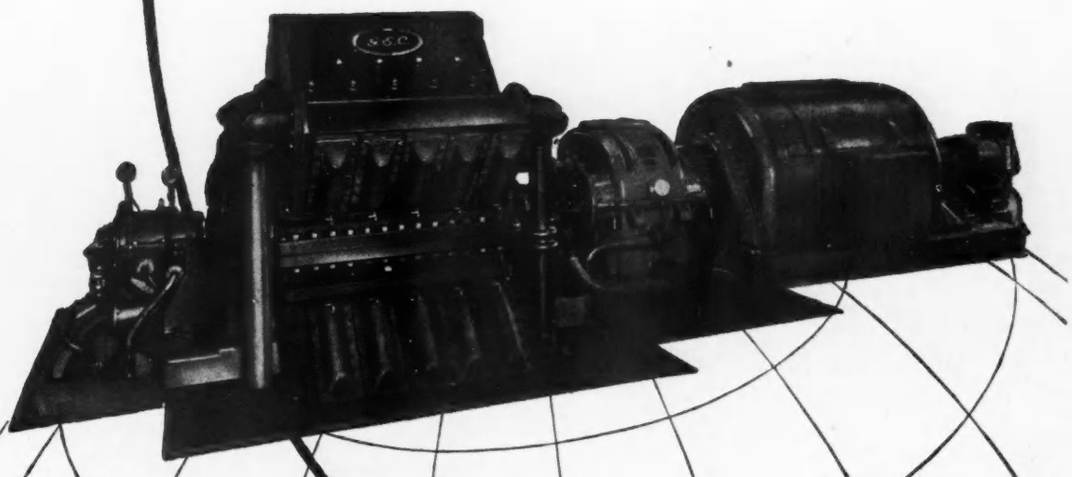

new centrifugal AIR COMPRESSOR

G.E.C.

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have the reach required!

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Basically, the essential features of the crane chassis and superstructure remain the same irrespective of the length of the jib or whether it is of the strut type (as illustrated) or the cantilever type.

These features may be summarized as follows :—

Centrally mounted superstructure giving an equal radius clearance and stability when handling loads over the front or back of the crane.

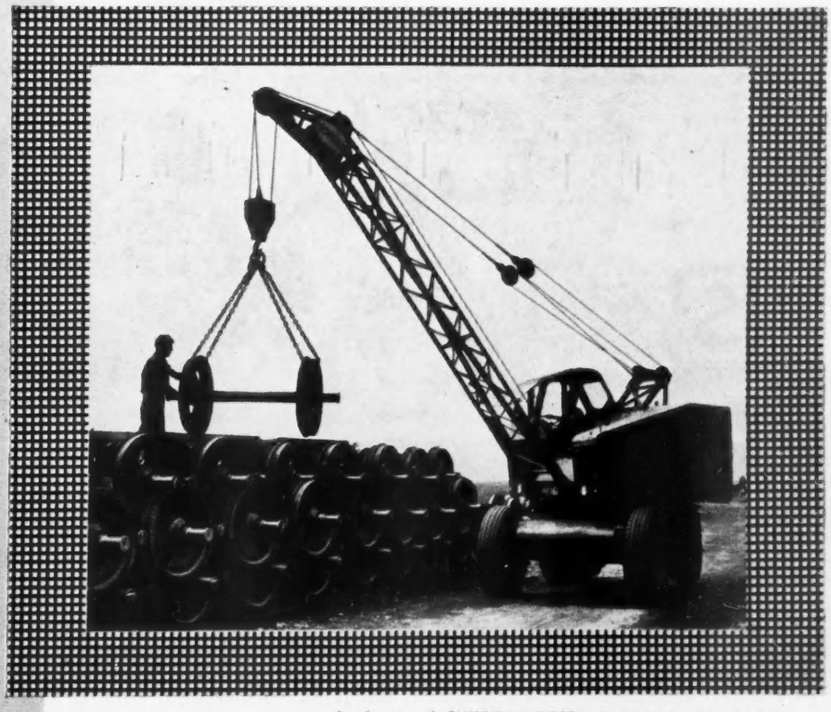
Easy control with no heavy levers to operate—just a finger touch controls all motions.

Flange mounted motors ensuring perfect and permanent alignment. All main assemblies are of unit construction.

Four-speed gearbox allows fast or slow travel according to the load being handled.

Hydro-mechanical brakes on all road wheels.

Fully interchangeable wheels, including tyres, rims, brakes and hubs. These components are interchangeable on all four road wheels of equal size.



By Courtesy of CAMBRIAN WAGGON & ENG. Co Ltd. CARDIFF

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F

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precise quality control of repetition castings

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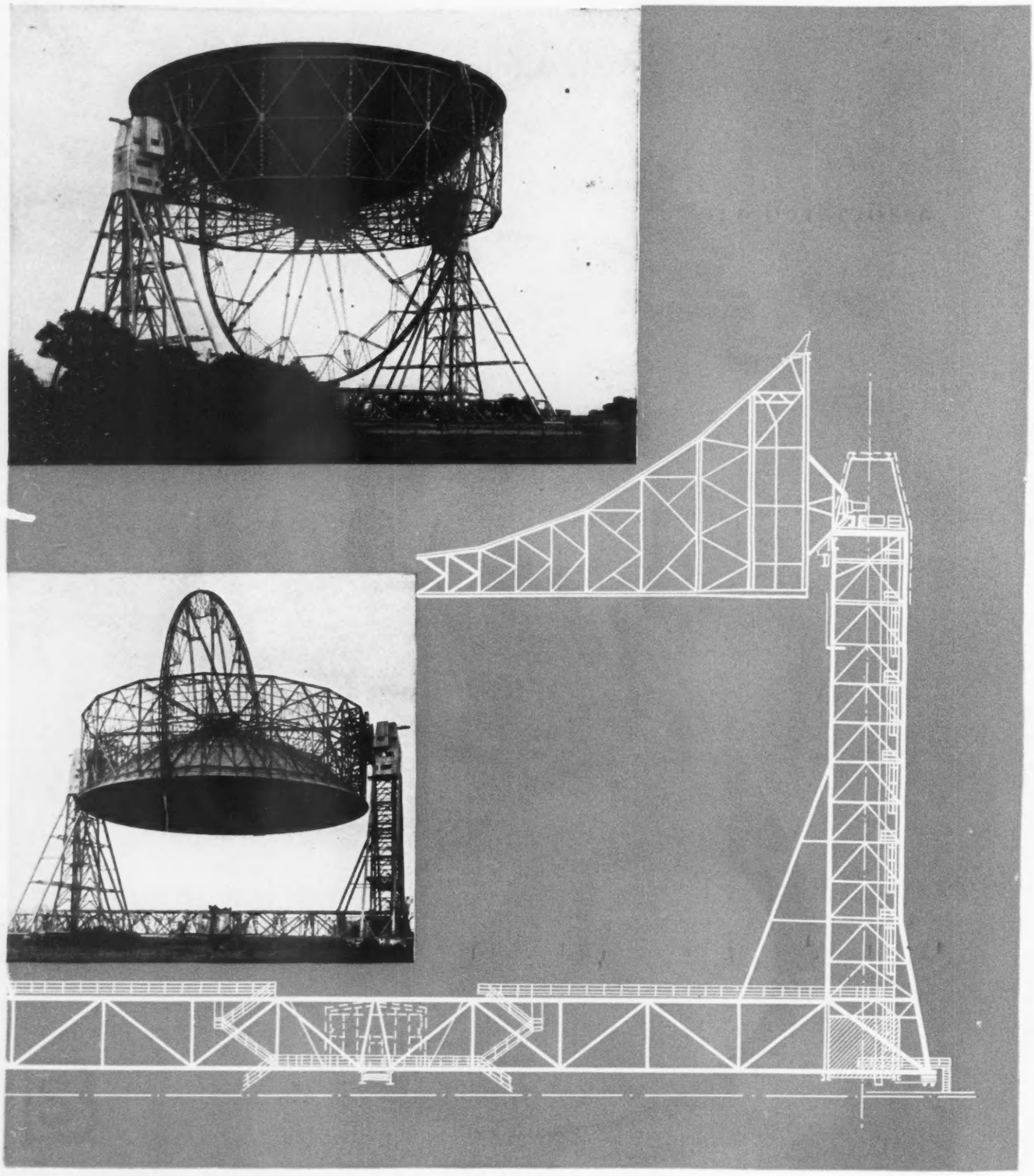

Radio telescope at Jodrell Bank built by United Steel Structural Company

Bowl diameter—250

Height of towers—180 *ft.*

Weight of structural steelwork—1,800 *tons.*

Consulting engineers: Husband & Company

UNITED STEEL STRUCTURAL COMPANY LIMITED
SCUNTHORPE · LINCOLNSHIRE

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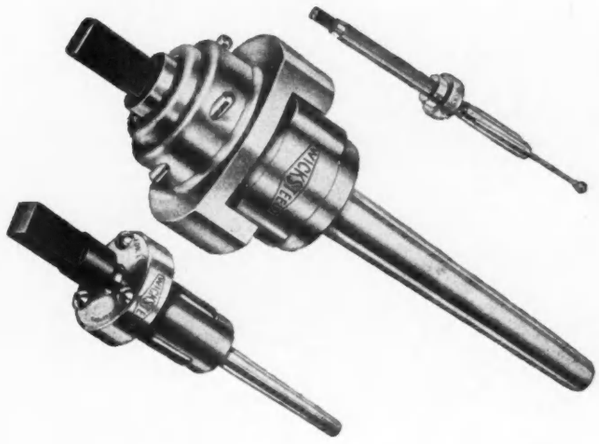

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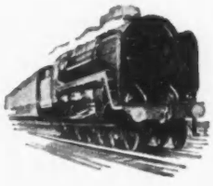

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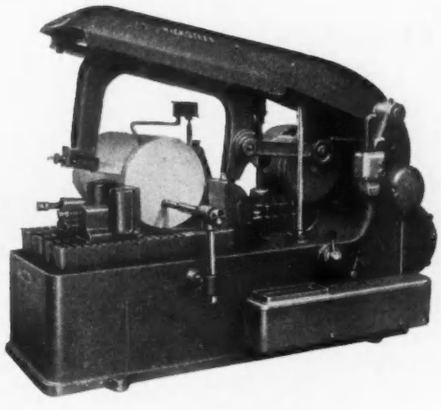
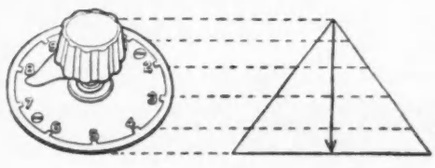


YOU INCREASE THE PRESSURE TO SUIT THE SECTION



HYDRAULIC CONTROL

SAWING MACHINES

Unique in design. Proved in practice. One simple setting and it's capable of dealing with any section within its range with blades of one pitch of tooth. The blade commences and finishes each cutting stroke with no pressure whatsoever. What a saving in blades!

FAMOUS FOR SPEED ACCURACY AND RELIABILITY

CHARLES WICKSTEED & CO (1920) LTD. **KETTERING. Tel: Kettering 3113**

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FLEXFLYTE

LIGHTWEIGHT **DUCTING**

for extremes of **PRESSURE & TEMPERATURE**

Where a sinuously flexible ducting, light in weight and of great tensile strength is an operating necessity ... specify Flexflyte. It has been time-tested under the most exacting conditions. Combined with a high resistance to abrasion, Flexflyte can handle a wide range of

PRESSURES	Internal — up to 70 psig External — up to 15 psig
&	
TEMPERATURES	From minus 120 Fahrenheit To plus 650 Fahrenheit

Toughly built with a spring steel wire helix, Flexflyte is available in a variety of standard diameters, coverings and linings. It can also be "tailored" to specific requirements. An illustrated technical brochure gives you all the details. Send for your copy today.

LIGHT
TOUGH
HEAT RESISTANT
FLEXIBLE

ANOTHER PRODUCT BY THE MANUFACTURERS OF SPIRATUBE

FLEXIBLE DUCTING LIMITED

103, SHUNA STREET, MARYHILL, GLASGOW, N.W.

Telephone: MARyhill 3729 *Telegrams:* FLEXIDUCT, GLASGOW, N.W.

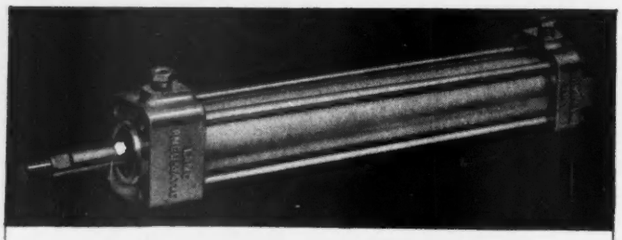
An associate company of George MacLellan & Co., Ltd., Established 1870.

PNEUTOMATION

power in the right direction

A push to production with the power of an elephant—that's PNEUTOMATION! Strong, steady power under perfect control, in the right place at the right time. The power to do anything from bell-ringing to jig-boring—and do it faster, at less cost. A wide range of standard equipment makes the system adaptable for any layout, any space. Simplicity of design, careful workmanship and completely non-corrodible materials cut replacement and maintenance costs, ensures that Lang PNEUTOMATION is a really long-lasting trouble-free pneumatic power system.

Pneutomation never forgets to operate



The 'Pneulang' basic cylinder unit, just one of the 264 cylinders available 'off-the-shelf'. The range of PNEUTOMATION equipment also includes many types of manual and automatic valves, lubricators, air flow regulators, pipes and fittings, etc.

PNEUTOMATION
energy under control

Plan with

LANG PNEUMATIC LTD

VICTORY WORKS BIRMINGHAM ROAD WOLVERHAMPTON Tel: 25221-2-3

Associated with Desoutter Brothers (Holdings) Ltd.

P1652

MARBAIX
FOR UNUSUAL MACHINES

MINUTES SLASHED TO SECONDS . . .

on the new

MARBAIX
M58 DISINTEGRATOR

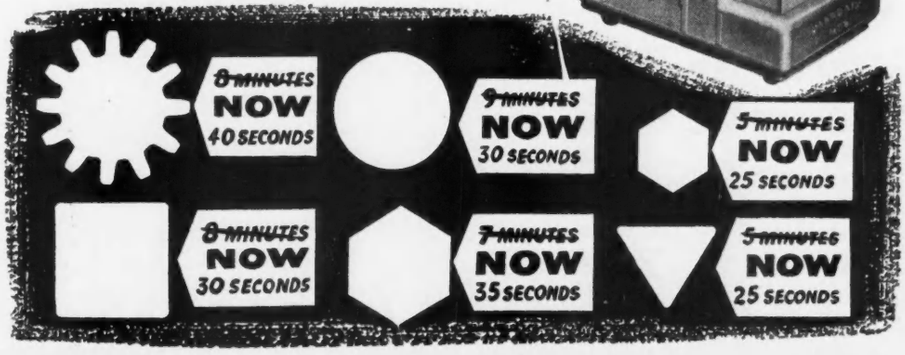
- **REMOVES** BROKEN TOOLS WITHOUT DAMAGE TO THE COMPONENT
- **CUTS** HOLES OF ANY SHAPE IN HARDENED MATERIAL, CARBIDES ETC.

. . . in fact any material through which electric current can pass.

The new MARBAIX M.58 disintegrator removes broken taps, drills, reamers, studs, etc., in a fraction of normal time, without damage to the component.
Holes, too, of any shape can be cut in hardened material, for subsequent finishing by grinding or other methods. Note the times for the various examples shown, and write today for full details to DEPT. E.1.

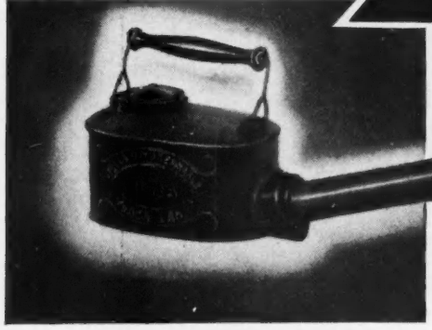
DEMONSTRATIONS ON YOUR OWN COMPONENTS GLADLY GIVEN.

★ **HERE'S HOW TO CUT COSTS**
Times obtained on Model M58-C (as illustrated)


8 MINUTES NOW 40 SECONDS
9 MINUTES NOW 30 SECONDS
5 MINUTES NOW 25 SECONDS
8 MINUTES NOW 30 SECONDS
7 MINUTES NOW 35 SECONDS
5 MINUTES NOW 25 SECONDS

Gaston E. Marbaix Ltd.
DEVONSHIRE HOUSE, VICARAGE CRESCENT, BATTERSEA, LONDON, S.W.11. PHONE: BATTERSEA 8888 (8 lines)

There's safety in numbers but One Wells Lamp can work wonders.



WELLS LAMPS

THE GUIDING LIGHT ON A GLOOMY NIGHT.

Also makers of Wells Waste Oil Filters, Oil Storage Cabinets, Barrel Pours, Lathe Drip Cans, Portable Industrial Oil Heaters, Lime Spraying Machines and Spray Guns.

A. C. WELLS & CO. LTD.,
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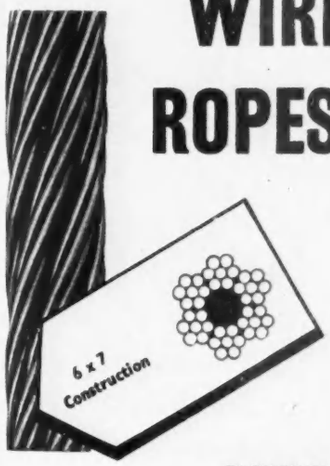
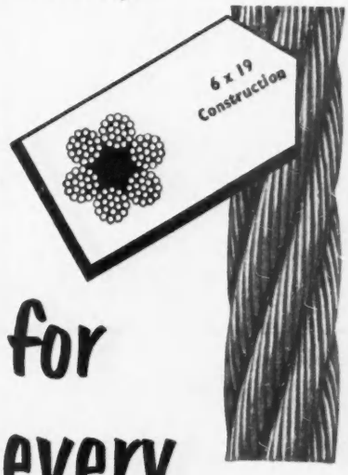
Telephone: HYDE 2953. Telegrams: UNBREAKABLE, HYDE

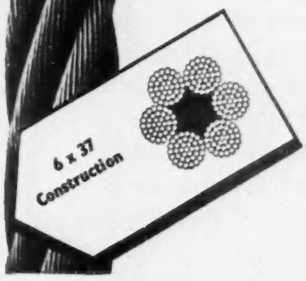
SHEFFIELD WIRE ROPES





for every purpose

If your job calls for wire ropes at all, then there's a place for Sheffield Wire ropes—for dependability, strength and a long working life.
Don't ever take a chance with wire ropes, always be sure—with Sheffield.



Also makers of the "RAM" RAILWAY WAGON PINCH BAR.

THE SHEFFIELD WIRE ROPE CO. LTD.
DARNALL, SHEFFIELD, ENGLAND

Thompson

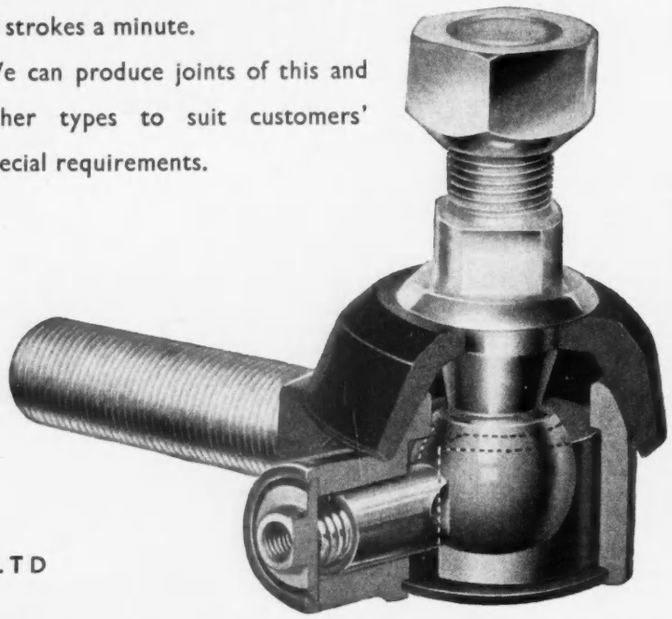
SELF-ADJUSTING BALL-JOINTS

These joints are self-adjusting and are very well made from fine materials. Used extensively on steering connections for every class of road vehicle, they are also valuable in a great many applications in general engineering, where their use can often save specially-made joints and at the same time give an improved result by eliminating backlash.

A SPECIAL-PURPOSE JOINT

The illustration shows a 1" eccentric-type self-adjusting joint. This forms the crank-pin and big-end bearing of a crank operating the cutter bar of a mower, at many hundreds of strokes a minute.

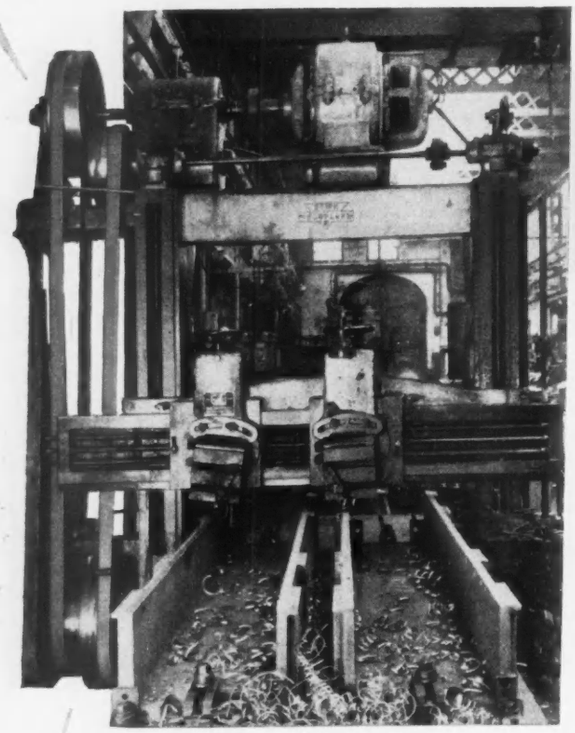
We can produce joints of this and other types to suit customers' special requirements.



AUTOMOTIVE PRODUCTS COMPANY LTD
LEAMINGTON SPA, WARWICKSHIRE

Every weekend the belts driving this Stirk Planing Machine required attention until Miraclo was fitted. After fourteen months' hard work the Miraclo belts showed signs of wear; they were turned over and, with the top ply running on the pulleys, an additional 18 months' life was obtained without any maintenance.

Miraclo has increased production by reversing the table more quickly and permitting greatly increased depth of cut. Try Miraclo on all difficult drives in your machine shop—it pays.



Photograph by courtesy of Chance Bros. Ltd., Birmingham.

The STEPHENS Miraclo NYLON BELT WITH CHROME LEATHER DRIVING FACE

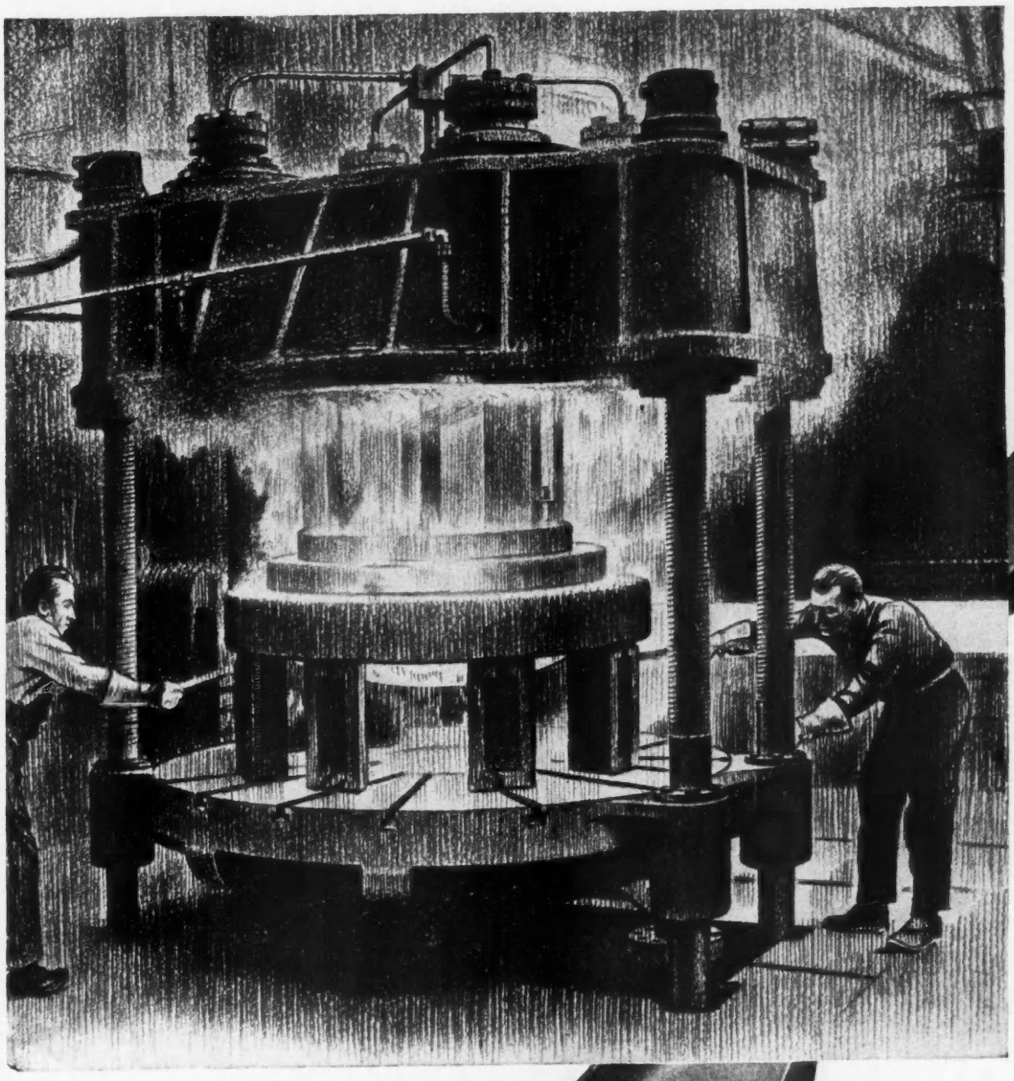
...turns the tables on belt wear...

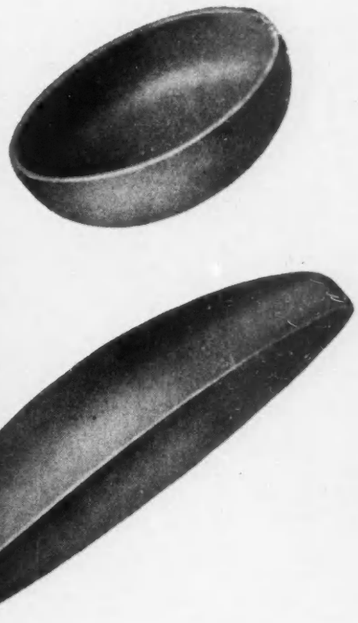
Send now for this 12 page colour Brochure No. 100 with its section on HOW TO DESIGN A MIRACLO DRIVE.

STEPHENS BELTING COMPANY LTD. · SNOW HILL · BIRMINGHAM 4

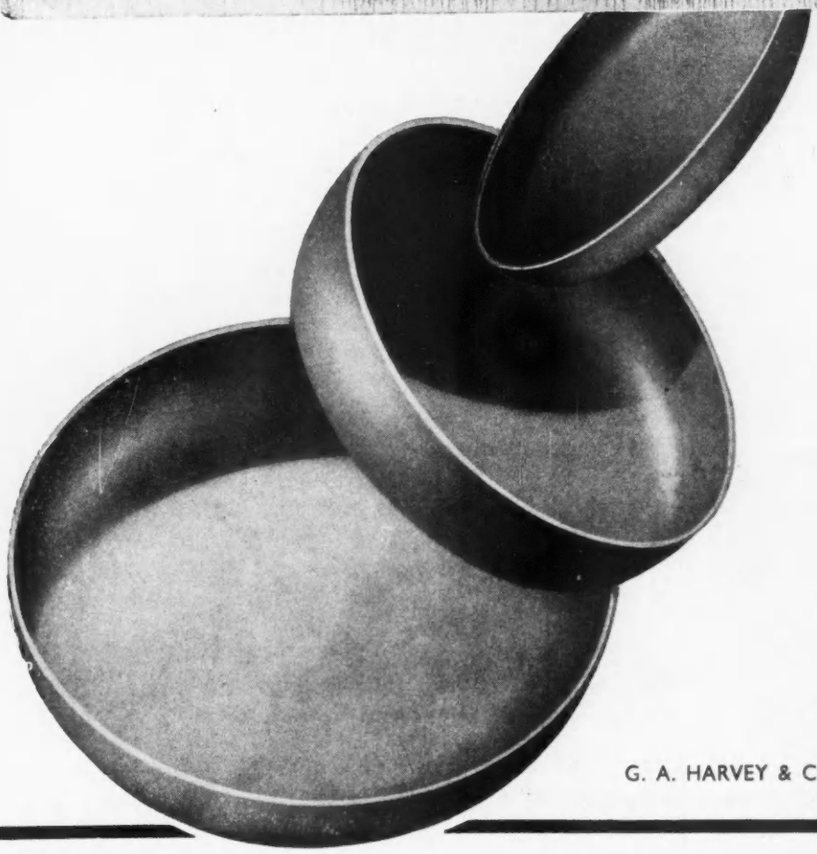
Northern Office and Works: Ira Stephens Ltd., Ashton-under-Lyne, Lancs.

S.76





DISHED and FLANGED ENDS



Fabrication of pressure vessels may be greatly facilitated by drawing upon Harvey resources for the production of die-pressed Dished and Flanged Ends.

Capacities range from 6 ins. to 9 ft. diameter. Edges are prepared for welding or riveting if desired.

STOCK SIZES: Ends pressed from Boiler Quality or Ship Quality Mild Steel up to $\frac{1}{2}$ in. thickness, in most sizes up to 7 ft diameter, are normally available from stock.

SEMI-ELLIPSOIDAL HEADS can be produced on the Rotarpress; diameters 5 ft. to 15 ft.; thicknesses $\frac{3}{8}$ in. to 4 ins. For details, please ask for List No. E965.

Harvey

G. A. HARVEY & CO. (LONDON) LTD., WOOLWICH ROAD, LONDON, S.E.7
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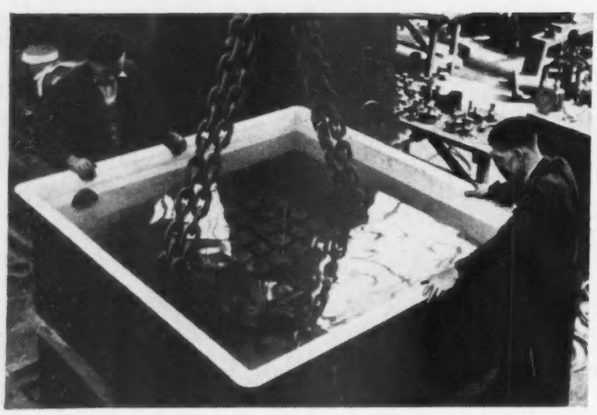
Precision in heavy engineering

An exacting task of precision engineering recently faced International Combustion in the manufacture of a number of transport flasks for nuclear reactor rods. The flasks, made under contract from Head Wrightson Processes Ltd. for the Dounreay and Harwell Atomic Energy Research Establishments, consisted of heavy castings with twenty-five 4-ft. long bores to hold the radioactive rods.

High precision machining was required throughout the diameter of the bores to ensure that the rods would move exactly in the guide holes without any risk of jamming. Equal accuracy was needed in fitting the 'O' ring sealed plugs, which close the end of the bores, to provide an absolutely gas-tight seal. Finally, a particularly exacting requirement in castings of this size, a high degree of freedom from 'porosity' was essential to make the component pressure-tight and prevent any risk of leakage by radioactive materials.

All these requirements were met by International Combustion by applying an entirely new conception of machining and welding techniques, backed at every stage of production by a progressive and rigorous system of testing.



Tests are carried out at every stage of production by International Combustion to ensure that components are machined to the exacting standards demanded by nuclear research. Here, the entire flask is submerged in water to confirm that it is pressure-tight.

IC

INTERNATIONAL COMBUSTION LIMITED

NINETEEN WOBURN PLACE · LONDON WC1 · WORKS: DERBY

Member of Atomic Power Constructions Ltd.
One of the five British Nuclear Energy Groups.

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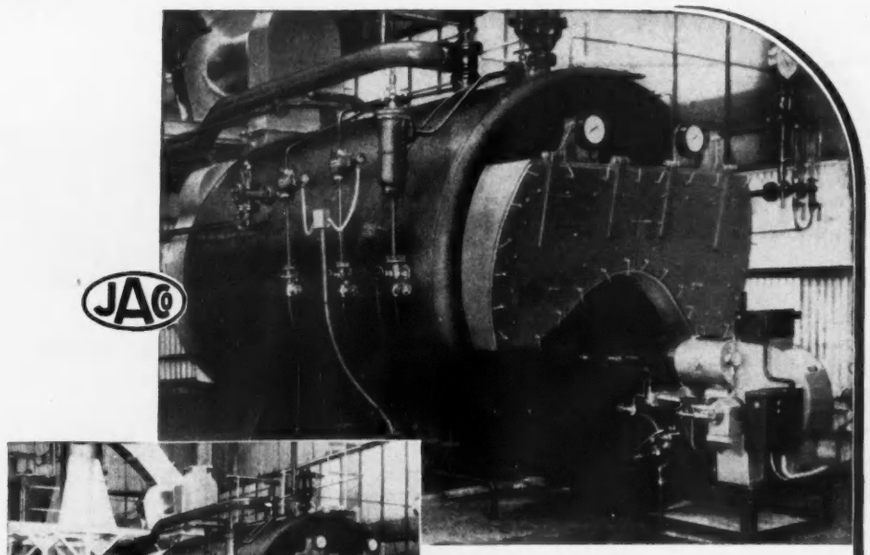

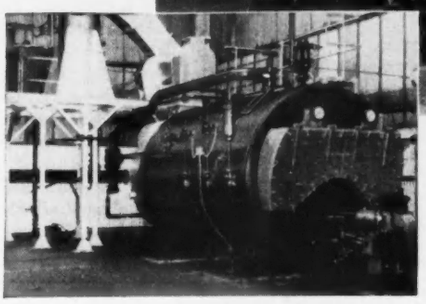

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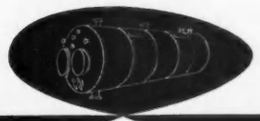
H·E· DRYBACK BOILERS

Whether the fuel selected be oil or coal a JOSEPH ADAMSON *High Efficiency* Treble Pass boiler is the right choice.

This plant has been installed to run on 950 secs oil with fully automatic control.

In an emergency, conversion to coal firing without serious loss of efficiency is readily possible.



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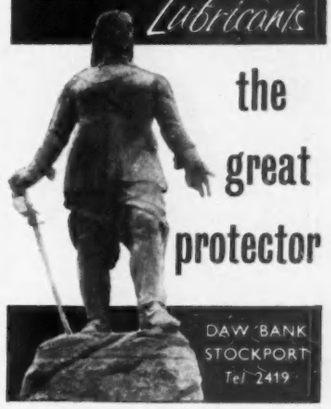

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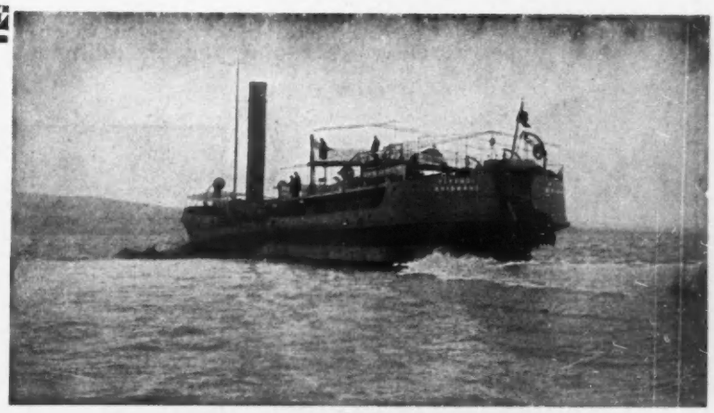
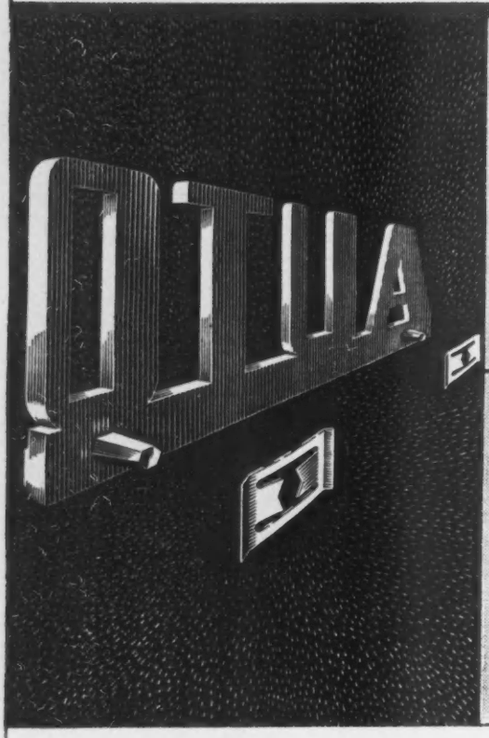
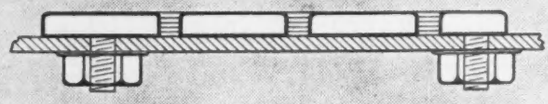


TWIN-SCREW TRAILING SUCTION HOPPER DREDGER "FITZROY"
built for the
QUEENSLAND GOVERNMENT, FOR ROCKHAMPTON
Dredging capacity: 1,000 cubic yards per hour
Vessel can suck from its 800-ton hopper delivering to a distance of 1,000 feet, to a height of 16 feet.

The logical advance in Retaining





OLD WAY

Threaded studs were spot welded (or inserted if die-cast) to the nameplate. To hold this in position, washers and nuts were laboriously assembled with great difficulty especially on blind applications.

THE SALTER WAY

Studs are cast in with the nameplate, and the Fixes are simply pushed on, even on blind applications. The whole is firmly retained with an even spring tension.

save material—reduce assembly time—cut costs

When it's a question of assembling components in any engineering field, Salter Retainers are the answer. They replace nuts and bolts, screws, cotter pins, and eliminate expensive threading and machining operations. A large standard range is at your immediate disposal, and we should welcome the opportunity to assist in developing special retainers to solve your problems.

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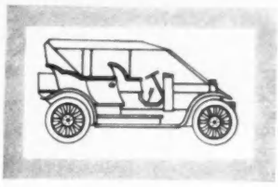

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. . . and help to make that era memorable.
The continuing success of Sterling Metals is due to their ability to supply castings of the highest quality in the desired quantities at the right time.
Today as in the past, Sterling Metals offer the greatest technical experience augmented by quality control of production which is second to none.
Sterling Metals are the acknowledged experts in casting aluminium and magnesium alloys by sand, die and precision mould processes, and in making engine blocks and cylinder heads in high duty iron.

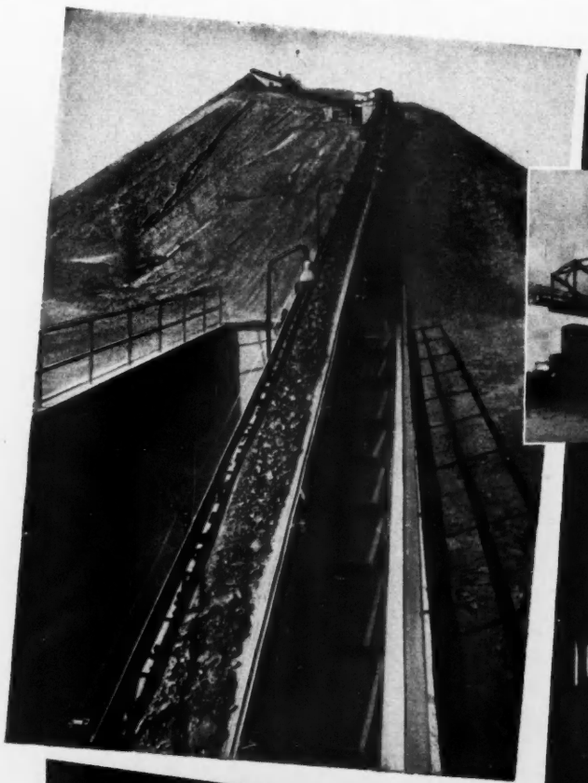
Sterling Metals are at your service

STERMET REGD. TRADE MARK

STERLING METALS LTD

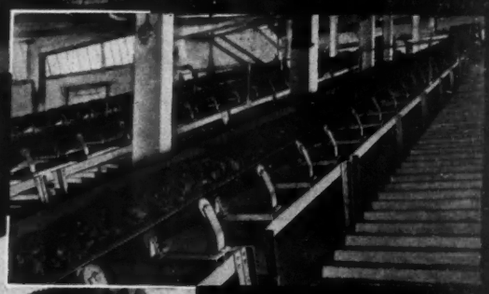
NUNEATON · Nuneaton 4221

Transmission casing in magnesium alloy for Massey-Harris-Ferguson Tractors used in Sir Edmund Hillary's Antarctic Expedition. By courtesy of Massey-Harris-Ferguson Ltd.



POHLIG

Mechanical Handling Plants



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Cranes
Lifting Equipment
Aerial Ropeways

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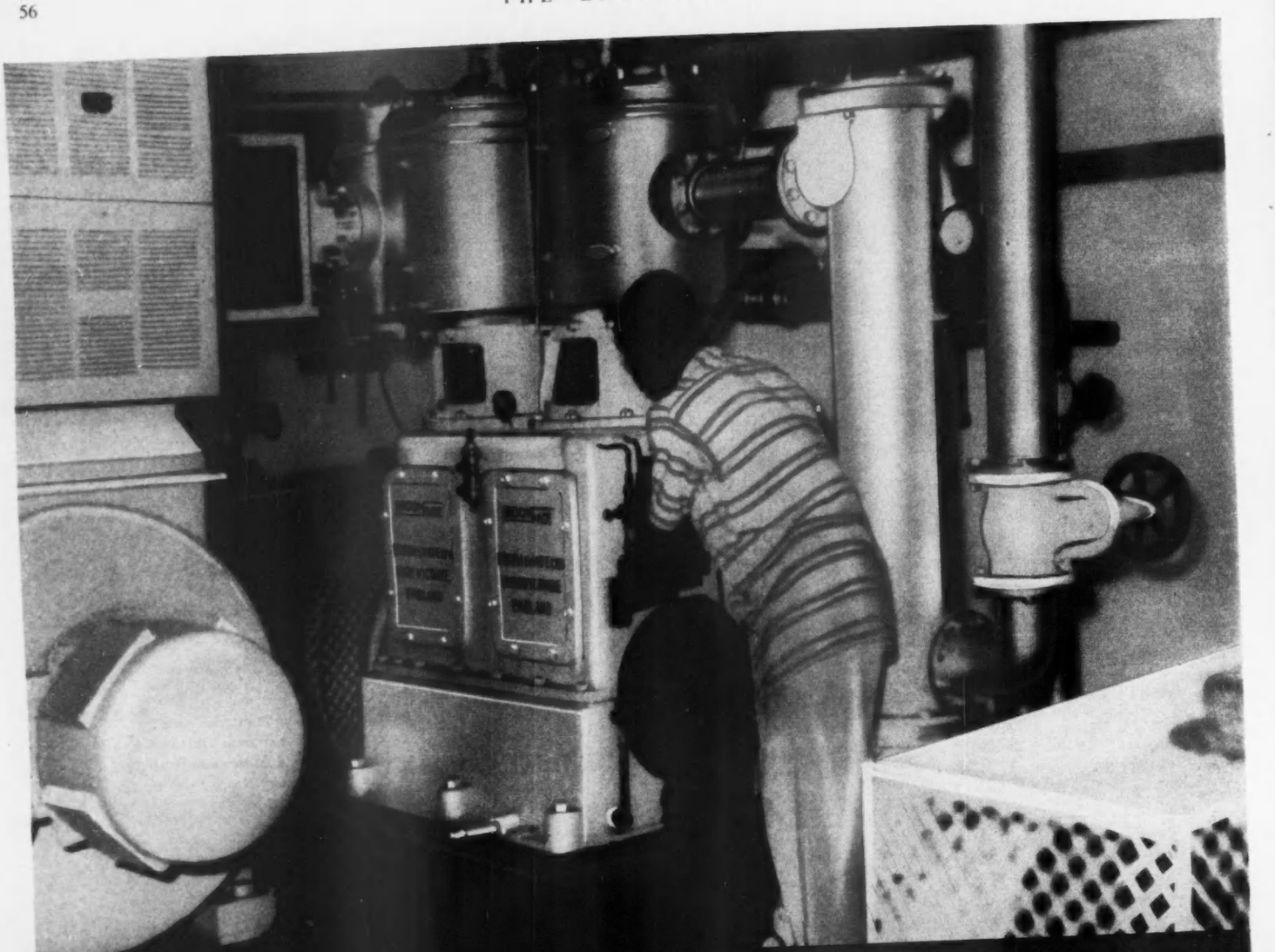

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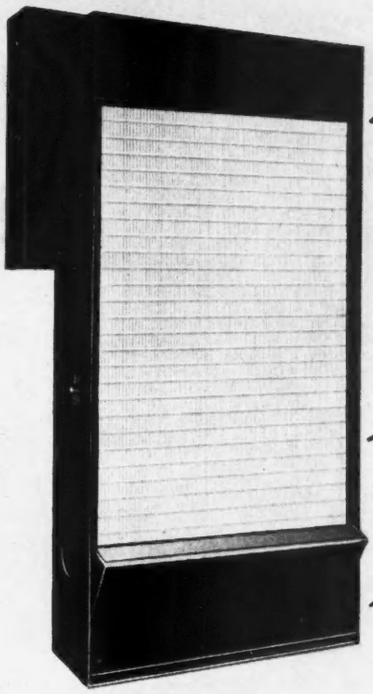

AIR CONTROL

AND

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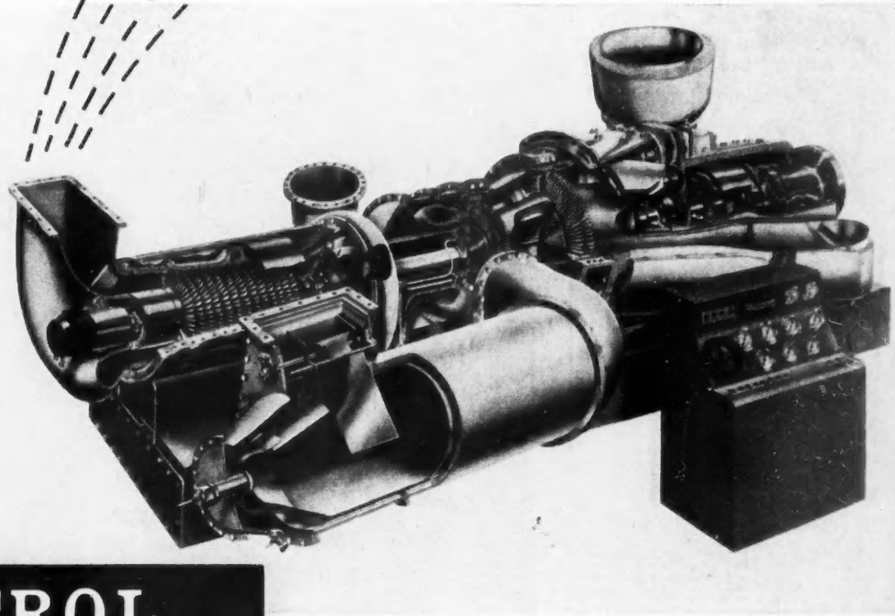
For their Ruston Mark TA gas turbines installed in the Middle East, Iraq Petroleum Co., Ltd. specified Air Control-built AAF Multi-Duty air filters. The AAF Multi-Duty is an original design of viscous impingement filter embodying a unique and extremely efficient system of self-cleaning mesh panels. There is no oil "carry-over" and the filter is virtually everlasting even under the severest conditions.
All over the world Multi-Duty installations are giving exemplary service. They are suitable for use in conjunction with engines, gas turbines and compressors—and for all heavy duty ventilation installations. There are sizes and duties to meet every need. May we send you full details?



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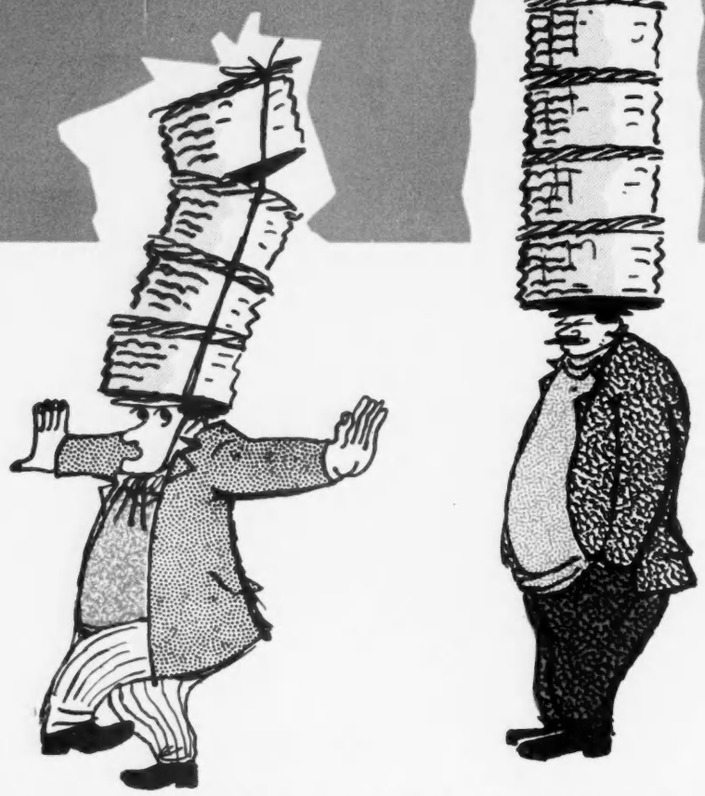

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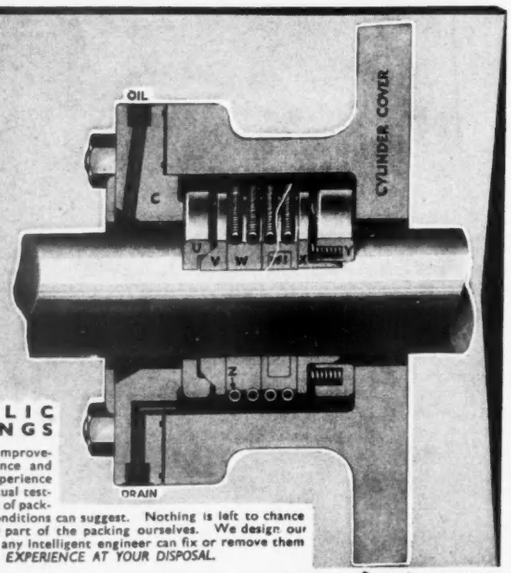

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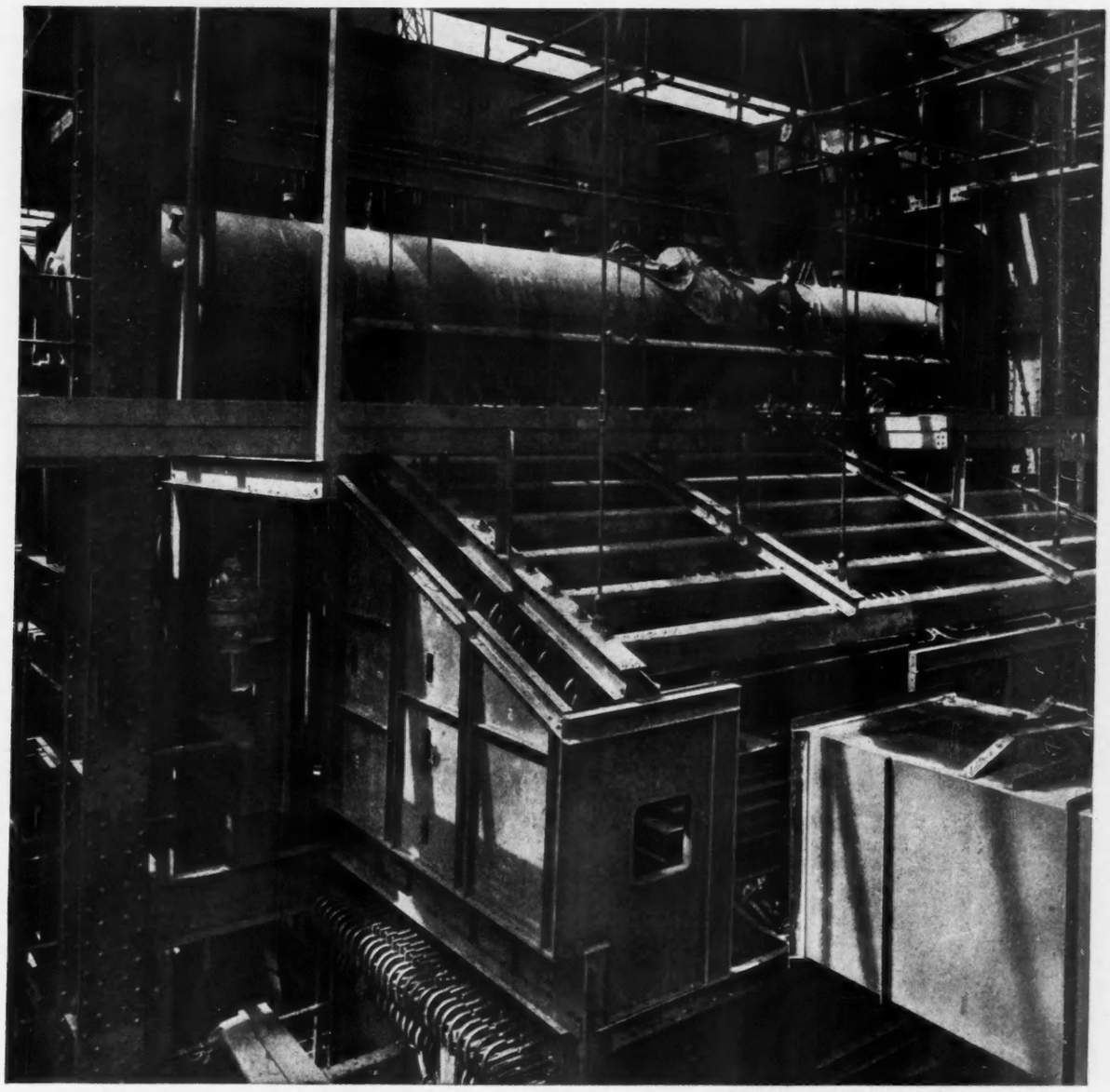

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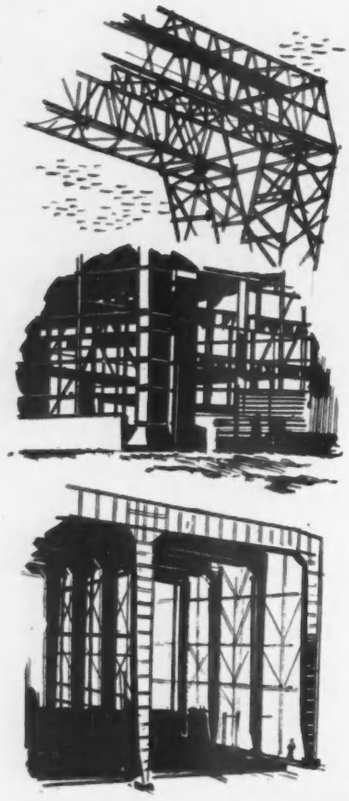

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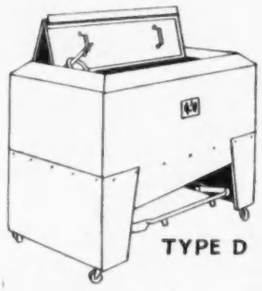

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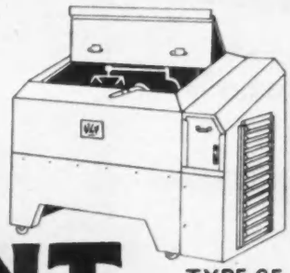

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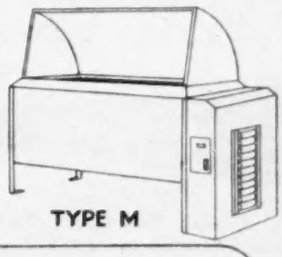

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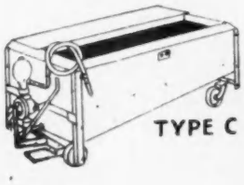

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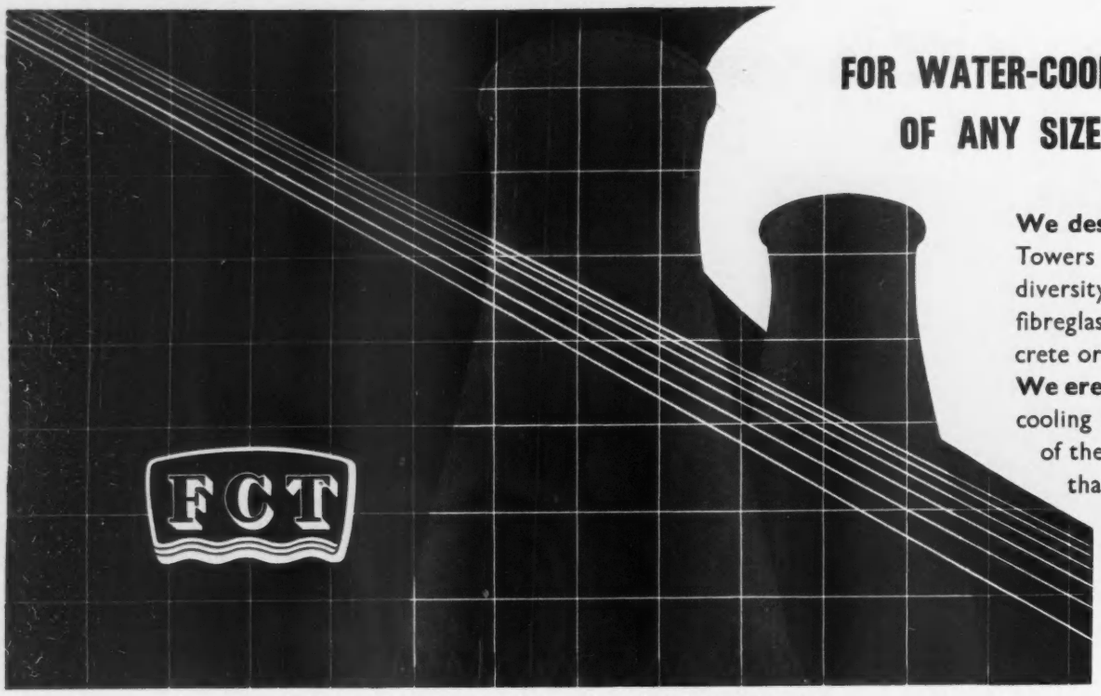

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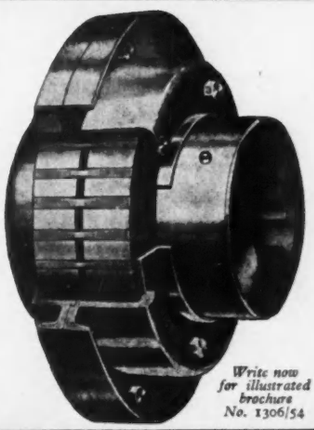

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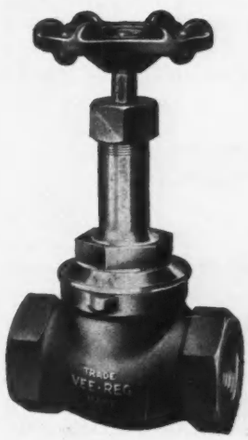

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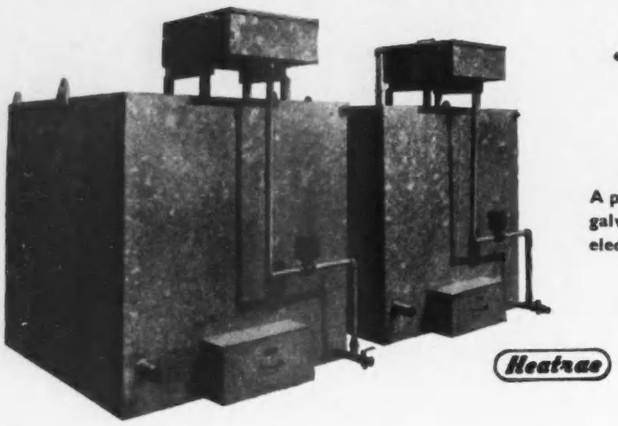

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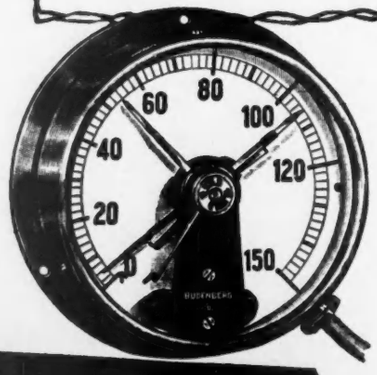

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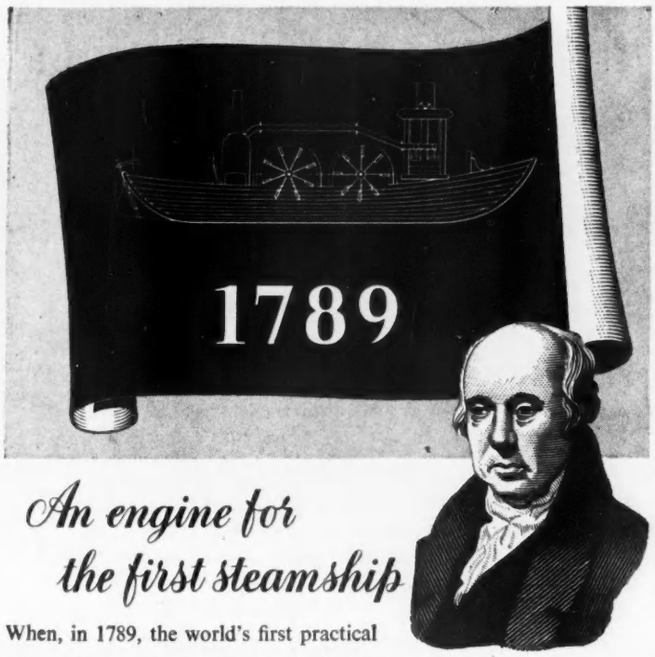

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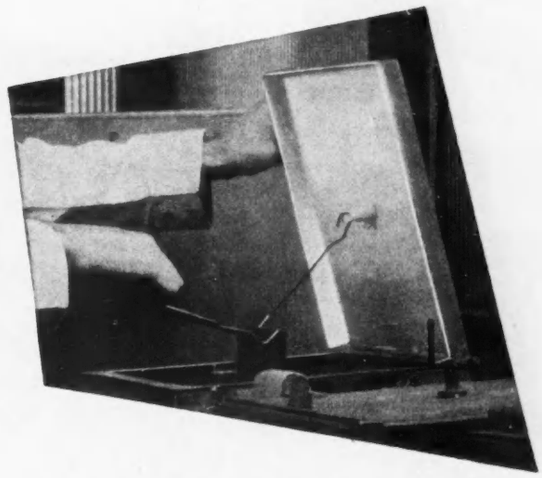

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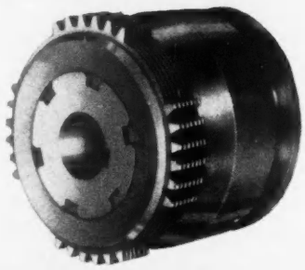

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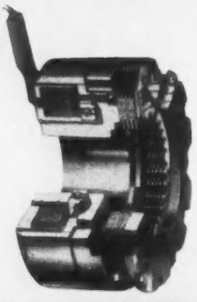

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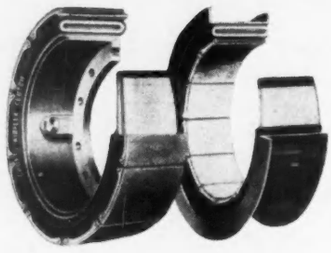

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THE ENGINEER

No. 5355 SEPTEMBER 12, 1958 VOL. 206

MORE FUSION

To-morrow, Saturday, September 13, the grandest (and, in some respects, perhaps the most grandiose) international scientific conference ever held will end in Geneva. After a fortnight in the great Tower of Babel that is the Palais des Nations, representatives from nearly seventy countries will pack their bags, cramming in whatever part of the huge supply of papers they can find room for, and return to their homes perhaps a little wiser than when they set out. We say " wiser " deliberately, and we are equally deliberate in saying " perhaps." Certainly many participants have become more knowledgeable as a result of this conference, but that was only to be expected. The knowledge gained, however, carries with it a lesson of wisdom that may be more important. It has been taught before, and not only at the first international conference on the peaceful uses of atomic energy. It is a lesson that has been preached anew, both implicitly and explicitly, by men of several nations, at the palace in Geneva. Professor Perrin, who presided over the conference, made it clear in his opening address (see last week's issue of THE ENGINEER). Dr. Bhabha, who was the president of the first conference in 1955, re-emphasised it in his verdict on certain of the work reported at the present conference. Invited to give his opinion on whether anything really new had emerged from the papers read on the subject of thermonuclear fusion, Dr. Bhabha said that it was noticeable that the ideas from the various countries had been similar in kind, and that this similarity was an indication of what secrecy had cost the world. In his view, the abolition of secrecy was the most important aspect of the conference as far as fusion was concerned.

Dr. Bhabha was, we are bound to fear, a little sanguine. It is true that the United Kingdom and the United States joined together in announcing, just before the conference began, that they had " declassified " their research programmes in the field of controlled thermonuclear reactions. It is true that, with rather a dramatic flourish, Professor Emelyanov presented to the secretary general of the conference four volumes containing more than a hundred hitherto unpublished Russian papers on work up to 1958. We must also concede Dr. Bhabha's point that the first big breach in the national barriers of secrecy surrounding fusion research was made by Academician I. V. Kurchatov in 1956, when he reported Soviet progress to his hosts at Harwell. Nevertheless, though he was pressed hard by journalists after making the presentation on behalf of the Russian delegation, Professor Emelyanov would not say that the U.S.S.R. would follow the U.K. and the U.S. in entirely freeing future work on controlled thermonuclear reactions. We must hope, however, that the Russians will eventually respond to this eminently sensible move in an equally sensible way. Certainly we know that some of the Soviet representatives at the conference favoured international collaboration in this field. Thus the eminent Russian physicist, Academician J. E. Tamm, also pointed to the close parallel between the reports and ideas from the two camps, and thought that co-operation between the three leading countries in this field was quite feasible. He suggested that there should be more international scientific conferences, but that they should be more narrowly based. He gave as a model the well-known " Rochester " conferences on high-energy physics. These now follow a three-year cycle, taking place in successive years in New York, Geneva and Moscow. Plasma physics was another field in which international exchanges could well be made on these lines. He saw no need to distinguish between " collaboration " and " frequent exchanges of information " ; in other words, there was no need actually to fuse the national research programmes into an international whole. This, of course, is typical of the Russian attitude. While the Soviets might well have joined in the European research undertaking of CERN, they chose instead to establish their own great nuclear centre at Dubna. Relations between CERN and Dubna are reported to be excellent, and we have already referred to their joint participation in the Rochester conferences. But perhaps an even closer liaison would be a good thing.

BRITAIN'S AIRCRAFT AND ROCKETS

Little room remains for doubt as to success of the annual S.B.A.C. Exhibitions in their principal function, that of supporting the business, particularly overseas, of the aircraft industry. But the fact that there is no international aviation show in this country seems regrettable when we notice how seriously the achievements of the industry have been distorted in public discussion in the last week or two. The most obvious instance concerns the firing of the " Black Knight " rocket, which, though very successful, does not imply the existence of either satellite-launching or strategic bombardment capability. It is the suggestion that the attainment of an orbit for a satellite is now within our grasp that clashes most obviously with all the lessons the free world has learnt in the last year or two. In fact our status is now shown to be equal that of the United States at the time when the " Redstone " rocket proved successful some five years ago. Nothing could be more obvious than that the setting up of a satellite was not possible at that time. Those of our readers who studied in our last issue the paper by Dr. Wernher von Braun will be well aware how much remained to be done when the three later stages of " Explorer " had reached altitude, while a very striking contrast between that experiment and the one in Australia last Sunday is that the first used propellants of an extra potency and the other a combination admittedly not used in other military vehicles and probably of low performance to reduce development costs. The successful firing of the " Black Knight " indicates no more than that British " rocketeers " have taken a sub-

stantial step forward in rocket research ; and the recovery of its nose cone suggests that the problems of protecting the explosive payload of such a rocket are on the way towards solution. But there is a long way to go before a British satellite could be put in an orbit.

But casual exaggerations about the magnitude of a country's achievements are perhaps of little account. Far more to be feared is the refusal to face the unpleasant facts now presented to the nation as the fruits over several years of the procurement policy of the Ministry of Supply. This policy has been not merely to deprive the country of certain kinds of aircraft, but also it has approached perilously close to a policy of depriving the country of the ability to develop such aircraft. To the chief executive of the S.B.A.C. there is now attributed the realisation that in at least one respect the Ministry with which the Society's members have, apparently, been content to deal is defective. But it is apparently not appreciated that when one single organisation is made responsible for virtually all aircraft procurement any major mistake on its part must be expected to be disastrous. It is not regrettable but exceedingly gratifying that it may be possible to make at least a partial and immediate rectification of the damage done by the Ministry's delays and errors at no heavier cost than the purchase price in dollars of transports developed by our now totally indispensable ally. Meanwhile the Ministry may perhaps make up its mind and so give the industry some chance to develop suitable aircraft for future service.

BRITISH ASSOCIATION AT GLASGOW

There is a very special flavour about a meeting of the British Association for the Advancement of Science. There are plenty of bodies which hold similar meetings ; and their programmes are similar, too. There will be sessions for the discussion of papers, evening social gatherings of one kind and another and excursions to places of interest. The members of the British Association take part in similar affairs. But the remarkable thing about B.A. meetings is the very wide range of the interests covered. It is, of course, true that all the subjects covered are supposed to be scientific. But an engineer, specially interested in Section G, can perhaps be excused for wondering whether in fact economics and psychology (Sections F and J, respectively) are fully scientific and frankly incredulous whether the term science can really be applied to much that is discussed in Section L, Education. For educating the young, even in a science subject, is much more an art than a science ! Furthermore, it is noticeable that amongst the social functions something artistic almost invariably figures. This year, for example, when the Association held its meeting at Glasgow which concluded on Wednesday of last week, there was a concert by the B.B.C. Scottish Orchestra on the previous Sunday night and the Reception to which the Corporation invited the members was held in the Art Gallery and Museum.

One has, of course, to get used to attending B.A. meetings really to appreciate them. A mistake very commonly made is to suppose that one should attend in particular the sessions of one's own Section and go out only on that Section's excursions. It was because that mistake was too freely made in the past that until a year or two ago the Association's meetings seemed to be developing along unsatisfactory lines. The various sections, and in particular Section G (Engineering), appeared to be attempting to compete directly with the learned societies in trying to attract highly specialised papers for presentation. That policy did not work at all well. For the quality of the discussion never approached that commonly reached at the meeting of a learned society, so that it was far from easy to attract people of high quality to present papers ; and, in addition, one of the basic ideas for which the Association had been formed, the purpose of " putting science across " to the public at large, was being lost. But within the last couple of years the Association has been deliberately recreating its ideas. Each Section, in consequence, can now express, to those who are going to present lectures or papers before it, a much clearer idea of the audience they will have to face. If possible, the lecture or paper should be comprehensible by any intelligent layman ; but if the subject is so abstruse that such an objective cannot be attained, then the presentation should at least be so free of jargon that anyone trained in the scientific method should be able to follow it. The consequence of the adoption of such ideas is that members of the Association are beginning, even more than they did in the past, to desert their own Sectional meetings in favour of the meetings of other Sections and even to desert their own Sectional excursions in favour of those arranged by other Sections. This, it seems to us, is all very much to the good. It is especially to the good for engineers. For it is a mistake to suppose that the only scientific branches of interest to engineers are Mathematics and Physics (Section A) and Chemistry (Section B). Every year it is worth an engineer's while to look with care at the programmes of every other Section, even such unlikely ones as Section D, Zoology, and Section K, Botany. For though there may be nothing of direct interest to be found, it is often true that the papers make reference to instruments or machines which engineers have had a hand in manufacturing.

It is interesting in looking through a list of the Sections of the Association to notice that Section G is in one sense the " odd one out." Engineering is the sole technology represented. Of course, within the context of the Association, it is the scientific rather than the practical side of engineering which is represented. That, no doubt, is why the vice-presidents of Section G almost all appear to be professors. But engineers who present papers before the Association often find it hard to phrase them in such a way that scientists, even if not laymen, can understand them. For whereas it is usually not difficult to give a clear picture to a layman of a physical fact, or theory, it is not easy to show why in applying that fact or theory an engineer goes about it in a particular way. For example, when one turns away from a scientific discussion as to why certain materials are physically preferable to others as canning materials for the uranium rods in a nuclear reactor, to the actual fabrication of the cans and the machinery for inserting and removing them from the reactor, one tends to get lost in technological detail. For the scientific side of engineering is very largely a matter of patiently acquiring and applying detailed knowledge, knowledge much more detailed than that provided by pure scientists. Nevertheless, a number of engineers who presented papers to Section G performed creditably in this respect. Furthermore, we were particularly glad to note how many of the Section G proceedings were conducted in Joint Session with another Section. It is particularly in the opportunity it provides for cross-fertilisation of ideas from one field to another that a meeting of the Association is valuable ; moreover, because engineers not only apply science but also make machines and instruments for other scientists to use, they come into contact with scientists in almost every field. Section G, in fact, is for that reason particularly well-placed to hold joint sessions with other Sections.

REGROUPING OF WATER SUPPLY

At the end of June, 1958, there were no less than 993 separate water supply undertakings in England and Wales. It is an astonishing number. All those bodies have recently been in receipt of a circular from the Minister of Housing and Local Government. It relates to the Ministry's desire to see amalgamations of one kind or another which would reduce the number. How small some of these undertakings are can be guessed from the fact that the approval of the Minister for a grouping of undertakings is only likely to be given if the " minimum requirement " is met that the resultant undertaking would need to employ at least one full-time water engineer. The Ministry set about encouraging amalgamations nearly two years ago. Since then the number of undertakings has been reduced by thirty-three and two compulsory orders and thirteen agreed orders at present awaiting the Minister's confirmation may reduce it by a further thirty-six. Three compulsory orders pending affect another twenty-two undertakings. The rate at which amalgamation is proceeding cannot be claimed to be high ; nor can the size of the resultant undertakings be necessarily regarded as wholly satisfactory.

There is still a growing demand for water for domestic, industrial and agricultural consumers ; but sources of supply are limited and not all centres of population are so sited as to be able easily to draw on local sources. Small water supply undertakings have neither the financial strength to construct works which will conserve water nor much ability to fight should pollution be threatened. They tend to compete with each other to make inefficient use of the more easily tapped sources rather than to combine in discovering how to make the most economical use of the whole resources of a watershed. There should be an abundance of water in this country to meet all needs provided it is satisfactorily collected, stored, distributed and preserved from pollution. But for our part, as engineers, we cannot see how systems of water supply can be effectively economic, and the water be properly shared unless the planning of new works and the operation of existing ones is based upon the proposition that the best use should be made of the waters from whole watersheds. We do not think, therefore, that water supply arrangements in this country will be fully satisfactory unless there is a very substantial reduction in the number of undertakings ; and we suggest, also, in view of the fact that some urban areas will inevitably have to draw supplies from distant regions that there should be an element of central control. In these circumstances, we find it rather disturbing that the Minister " is not on the whole dissatisfied with the progress so far." If water supply is to be placed on a more satisfactory basis within a reasonable time, progress will need to be much more rapid than it has proved to be over the last two years.

THE NINETIETH T.U.C.

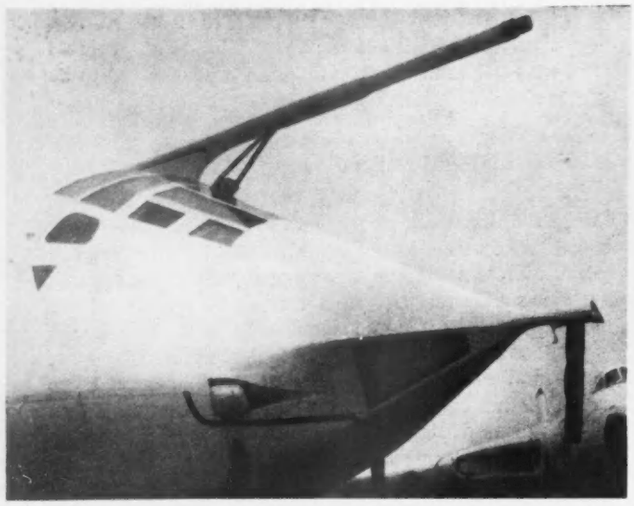
The Trades Union Congress, which assembles annually during the first week of September, has often been described as the parliament of organised labour. Its debates, inconclusive though they may sometimes seem, express the views of trade unionists upon various matters of national and international significance. The resolutions of the Congress have come to be looked upon as, at least, some kind of a guide to trade union policy. But the T.U.C. is not an autonomous body. It is an affiliation of many unions and groups of unions, the membership of which now totals more than 8,000,000. This year's Congress, the ninetieth, was held at Bournemouth last week. Those who participated in it no doubt went away convinced that their deliberations had been of the utmost importance to the future of British industry and trade. On the other hand, many who have studied the daily reports of the proceedings may well be left wondering if the trade unions, as represented by the Congress, are as fully realistic as they might be in their approach to the economic and industrial problems of the day. During the debate on economic affairs, for example, there was no indication that the unions are willing to consider a change of attitude towards wage claims. Opposition to any suggestion of restraint was again affirmed as stoutly as it has been for some years past. Certainly, some fears were expressed by delegates that in the coming months unemployment may increase but, should those fears unhappily be fulfilled, the unions declare that they would be entirely blameless. It is, of course, quite proper for the unions to defend the principle of free collective bargaining, a principle of which this country is proud, but they should not be blind to the fact that employers in industry are just as anxious to retain that principle. As a spokesman for the Institute of Directors put it a few days ago, the trade unions are not the only bodies who are interested in the welfare of the workers, for employers, who depend entirely on the efficiency of their workpeople, have exactly the same interest at heart. Plainly, at present, industry is losing some of its momentum and, in addition, the country's export business is not as good as it ought to be. A continuation of the wages scramble of recent years can only aggravate that unhappy situation. It is a pity that those who took part in the ninetieth annual session of the T.U.C. evidently thought otherwise.

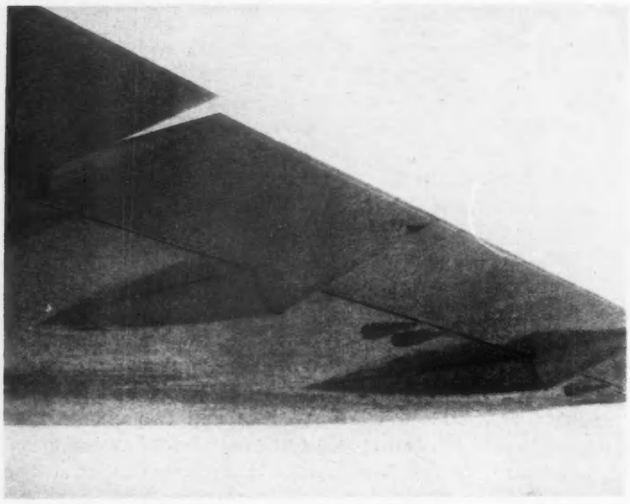
The Engineer— 100 Years Ago (SEPTEMBER 10, 1858)

" MIDDLE-CLASS EDUCATION."

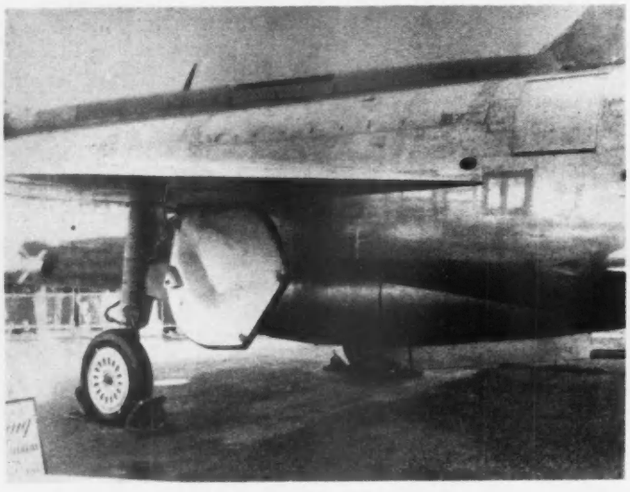
" The education of a man, or of a boy who has to be made a man, is designed to be either useful or ornamental, or both. With mere ornamental education we have nothing whatever to do ; it is easy to discover, and as easy to impart ; almost every pedant can teach much of it. It is with useful education that we have daily to do . . . .

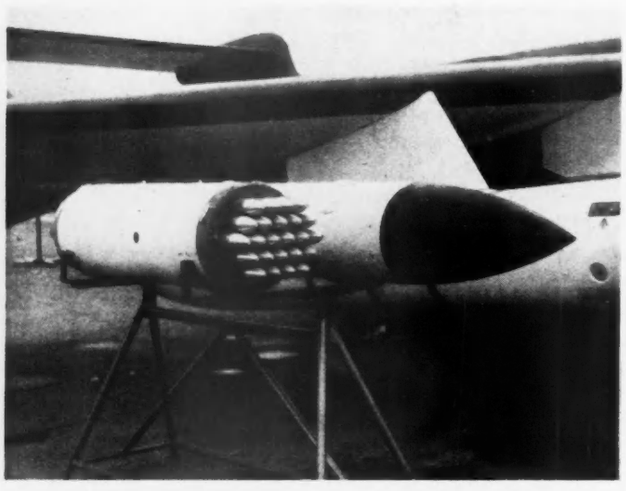
" Now useful education changes with the times. Plainly, the primary education for the multitudes of the middle classes in these days is a scientific one. Mechanics, hydraulics, electricity, chemistry, and astronomy, with the sciences upon which these to a certain extent rest, and others which grow out of these—such are the things which should be brought to the knowledge of the youth of the nineteenth century, if we would have them walk worthily in the path before them. A hundred years ago the study of science opened no prospects to the many. To an occasional devotee it indeed afforded bright and substantial visions of wealth and fame ; but the majority of men would then have done no worse, so far as their temporal prospects were concerned, in studying deportment under one of the Turveydrop family, than in pursuing much of the science of that day. But science has lately kindled new lights, and stood forth glittering with new attractions, and now has many an honour, and many a fortune too, to bestow upon her followers. Nor is the effect of a scientific education upon the mind either pernicious or trifling. On the contrary, it cultivates a true and abiding greatness. It teaches the man, as Professor Faraday recently remarked, ' to deduce principles carefully, to hold them firmly, or to suspend the Judgment ; to discover and obey LAW, and by it to be bold in applying to the greatest what we know of the smallest.' We have, we are aware, stated our argument very scantily ; but we can just now afford it no more space. It affects a subject which readers can reflect upon for themselves, and our main object is to induce them to do so."



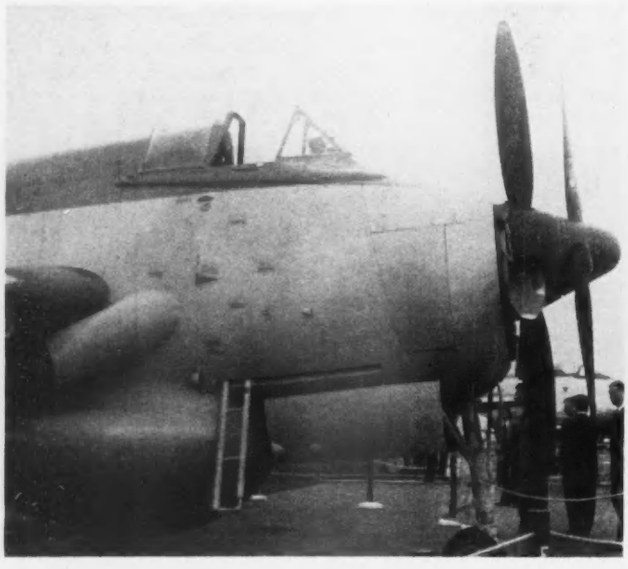


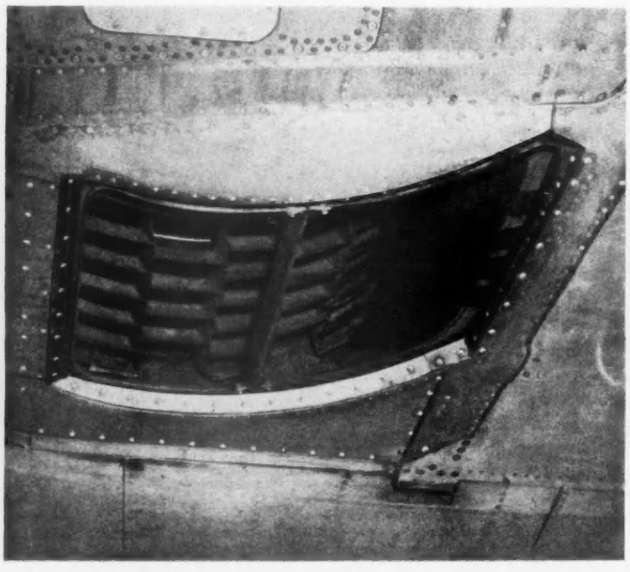
(Left) The "Victor" is seen here with a refuelling probe and a light to illuminate it. Notice the vortex generators before and in the cooling air intake. (Right) The ailerons of the Mk. I "Vulcan" are replaced by elevons on the Mk. II. Large fairings with inlets and outlets for cooling air have appeared to house the operating mechanism, but the provision of mass balances leads to speculation as to whether control is irreversible in all modes





(Left) The trailing edge of the aileron of the "Lightning" thickens progressively inboard: the fin is now larger. The two wires projecting from the fuselage probably operate refuelling valves connected to the vertical tank. (Right) The "Sea Vixen" can carry unguided rockets, both in retractable launchers below the nose and in under-wing pods: pods are seen here with and without the frangible nose cone



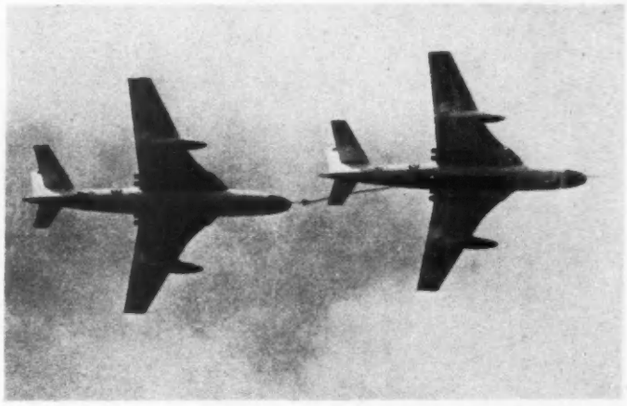


(Left) On the "Gannet" A.E.W. Mk. III, the tail pipes emerge well forward on the fuselage. The central radome can be seen: the access ladder collapses in the manner of a parallel ruler as it folds forwards. (Right) The burying of the engines in the wing root of the "Comet" causes the cascades of the thrust reversers to lie in deep recesses

S.B.A.C. Display

No. II—(*Continued from page 366, September 5*)

The 1958 Flying Display and Exhibition of the Society of British Aircraft Constructors took place last week at Farnborough; the Royal Navy and Royal Air Force took part in the programme; here are seen "Valiant" aircraft demonstrating flight refuelling. We give below some impressions of the aircraft and missile engineering seen on static exhibition.



Missiles

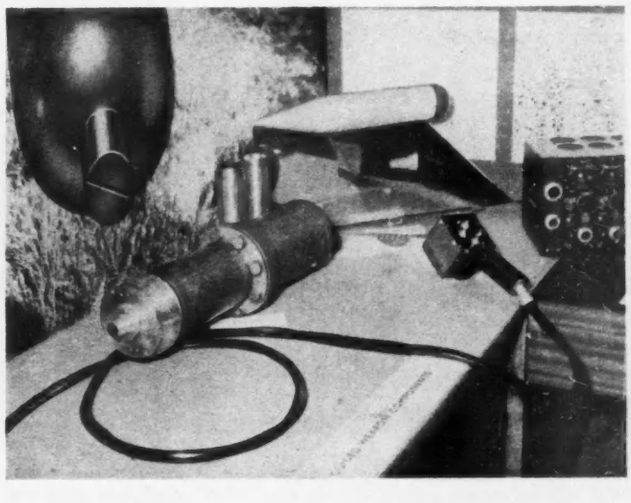
A NUMBER of missiles were displayed in more or less realistic conditions out of doors. These included the Pye weapon for use against tanks or strong points, seen in our illustration. This is one of the numerous family of wire-trailing vehicles, two large spools of wire being carried in the glass-fibre nacelles at the tips of the horizontal wings. The wings are composed of honeycomb with light alloy sheet folded round and bonded to the cores; the vertical wings carry flares for ease of tracking. The centre and near sections of the body are occupied by a two-chamber solid-propellant motor made by Bristol Aircraft, Ltd., each chamber having a nozzle plate attached by a fine screw thread. The front chamber has eight nozzles evenly disposed around, and exhausting through recesses in, the fairing surrounding the aft motor; the problems of centre of gravity travel suggest that the front one will be the boost chamber. The fact that both pairs of wings are the same size suggests that the vehicle will not "twist and steer"—although there is apparently no means of generating rolling moments—and will not need a gyroscope to determine which wing can, at any instant, respond to "up" or "left" commands. The operator has a small joystick operated with his thumb, and follows the missile through binoculars with a rapid focusing device; the viewer shown acts as a periscope. A rather bulky control box transforms the operator's commands to a form in which the missile can use them. A simulator and trainer has, it was stated, been used in the development of the weapon, and it is claimed that on it an operator can very cheaply acquire adequate skill in guiding the weapon.

Also seen in public for the first time was the Avro powered guided bomb. A study of photographs has now shown that our account in No. I was inaccurate in one respect, the actual missile flown having anhedral on the wings; this means that four different configurations are to be seen on the full-scale and model exhibits made up as follows: two with straight delta main and fore planes, one of which has a double-wedge fore-plane section; the actual vehicle, with anhedral on the outer wing panels; and another model with anhedral and the tips of the fore-plane cut away at an angle corresponding to about Mach 1·5. Viewed in the light of the invariable trend for any particular pattern of power plant to move into higher performance brackets, so that missiles cruising at Mach 1·8 are now being equipped with turbo-jets, this is a surprising vehicle to be introduced in the late 1950s. Since the propellants are the low-specific-impulse combination of kerosene and hydrogen peroxide, the endurance in powered flight must be relatively short, and even with the advantage of launching at a height of 10 miles, the missile would appear to have no pretensions to long range.

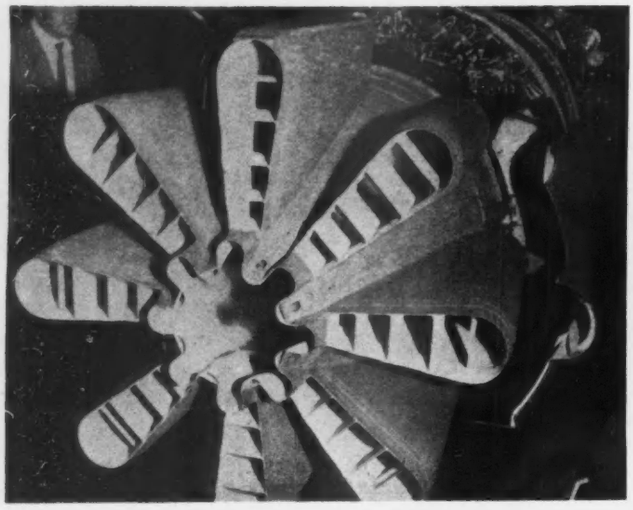
Some light was also shed on the performance of the de Havilland "Firestreak" air-to-air missile. It was clear that, denied direct measurement of range and, naturally, any control of thrust, this vehicle would have only an exceedingly limited ability to execute interceptions, and that this limitation would be accentuated by the impossibility of providing a fusing system capable of selecting the optimum point of detonation on a "miss" trajectory. The severity of these restrictions is made clear by an exhibit of an English Electric "Lightning" showing that the missile—whether both are discharged is not stated—is confined to pursuit attacks, and does not accept a target until it is virtually straight ahead and, apparently, at the same altitude. It is claimed for the active homing element of this weapon system that it is capable of controlling a collision-course interception, although centre-body radomes have been found inadequate in this respect overseas.

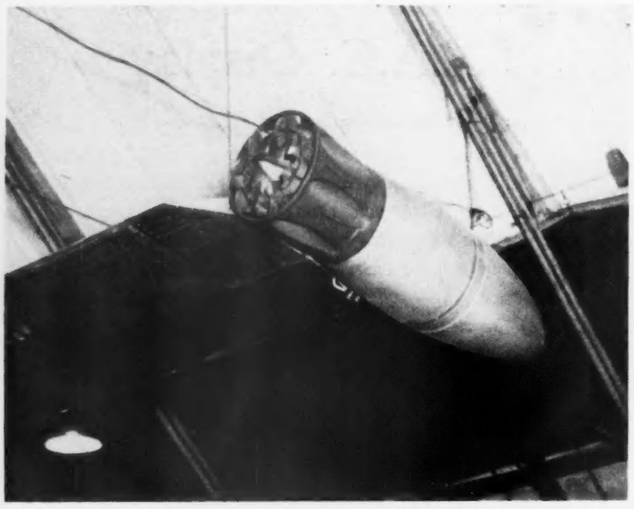
The Armstrong-Whitworth "Seaslug" ship-to-air weapon was shown in its developed form (illustrated) as a propulsion test round: it will be recalled that it is now, in common with the remainder of British anti-aircraft rockets, driven by a solid-propellant motor. It has been disclosed that in a recent firing from H.M.S. "Girdle Ness" of a salvo of two missiles, the first struck the "Firefly" target and the second the largest piece of wreckage: it was not made clear to what extent the system was subjected to casual or deliberate foreign radar transmissions, target evasion, or saturation of the defence with many targets.

There was shown on Sunday, the day on which the first flight was made, a model of the "Black Knight." This was described as an R.A.E. test vehicle, built by Saunders-

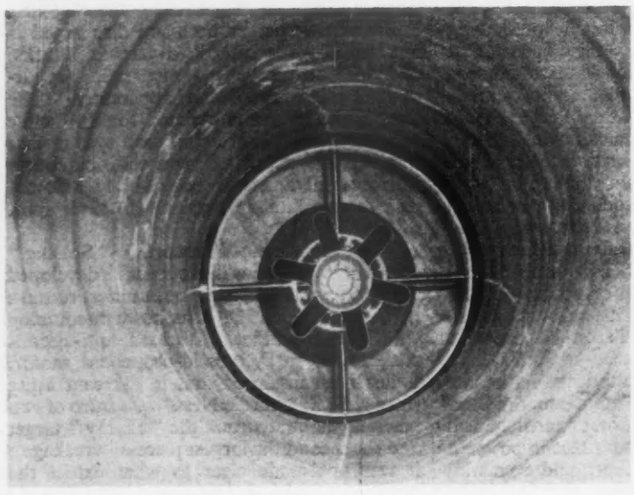


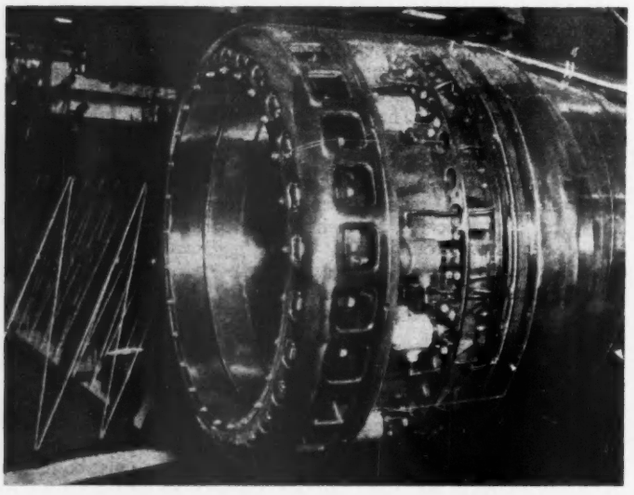
(Left) The Pye missile for use against tanks and strong points has solid propellant boost and sustainer motors, the former discharging through eight small nozzles behind the wing roots. (Right) The coils of wire that are paid out from the wing-tip pods are seen beyond the sustainer combustion chamber



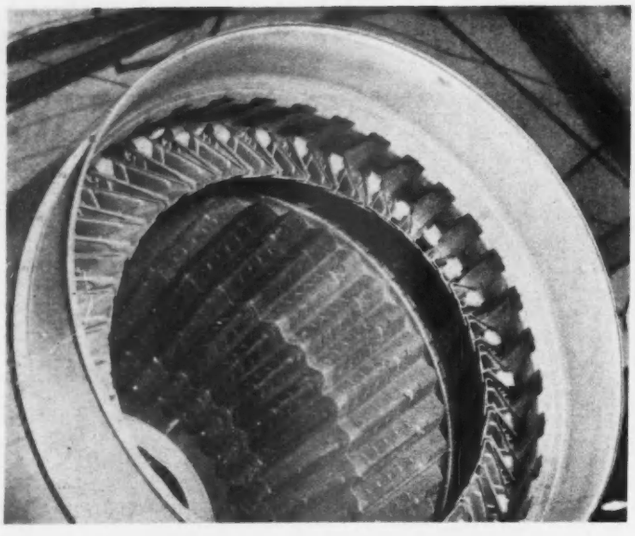


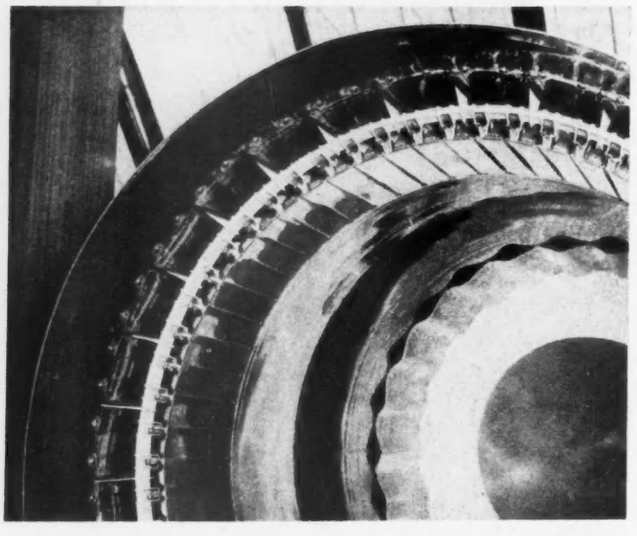
(Left) A " Conway " developed for use in one pod of the Boeing 707-420 ; the top lobe of the silencer is shaped to fair into the pylon. Notice the covers for the cascades, which move in unison with the internal doors, being driven by the twin rams above the tail pipe (Right) The tip jets of the " Rotodyne " now have noise attenuators like the one seen in the static exhibition : about 4 dB reduction is expected



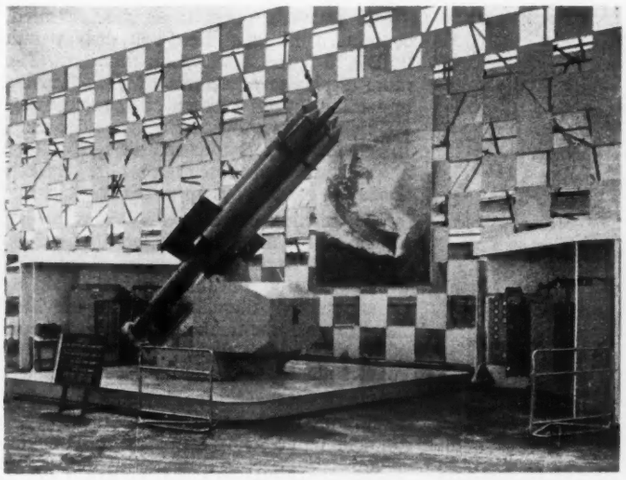


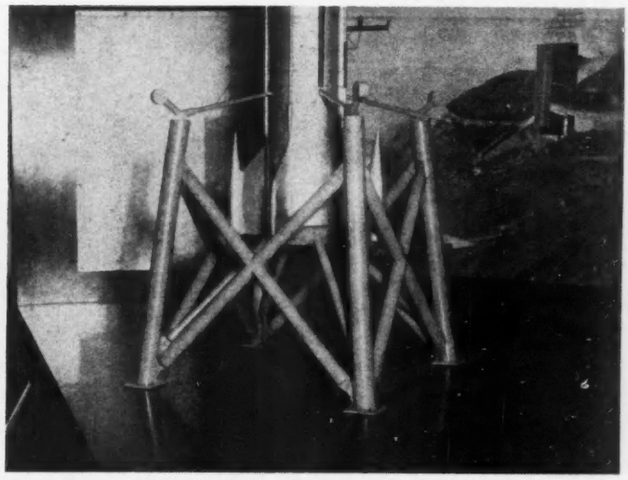
(Left) The flame-holder of the " Sapphire " A.S.SA7 is mounted close to the turbine, just downstream of the ring of six nozzles. It comprises a single heavily convoluted gutter with, as can be seen, a swirler at its centre. The tail pipe attaches directly to the turbine ; the gap seen above is a transparent section for display purposes (Right) The variable nozzle for the " Javelin " takes the form of a sharp-edged restriction, the segments of which are moved in and out by bell-cranks linked to the ring seen through the apertures in the outer shroud





(Left) The solar afterburner of the 17,000 lb thrust Bristol " Olympus " 201 gives fully variable reheat up to a maximum of 24,000 lb thrust. The vanes are forced outward by gas pressure until the large rollers behind them contact the tracks in the big movable outer shroud, the position of which is fed back to the control system by a Pacific potentiometer mounted just outside the afterburner (Right) The variable nozzle of the " Iroquois " is of a quite unusual complexity. It has sixty sets of inner and outer segments, positioned by a similar number of machined curved tracks, which, under gas pressure, bear against the rollers on the built-up ring, which is moved backward and forward by rams. Beyond the air-cooled radiation shield on the display engine is a blank





(Left) A solid-propellant "Seaslug" propulsion test on trial launcher; notice the shoes on the boost motors to fit the operational triple launcher. Surrounding it are examples of ship-borne test gear. (Right) The launcher of the "Black Knight" carries the vehicle by its engine mounting; the side supports are counterbalanced to swing clear

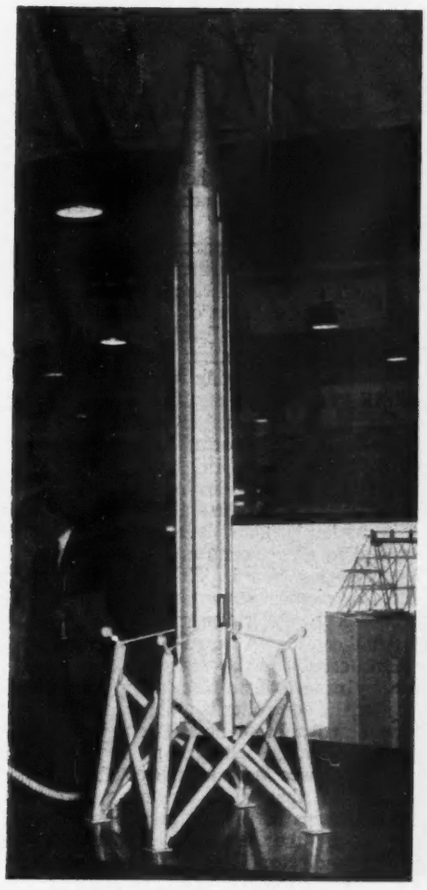
Roe and using Armstrong Siddeley engines. Our illustration shows that it is of the simple, cylindrical shape common to all but the most advanced missiles: while it is probable that the re-entry body separates, there is no evidence to support this. The propulsion and control arrangements can only be inferred, but the suggestion has been made that the oxidant is high-test peroxide. It is an entirely new departure for Armstrong Siddeley to build engines for this low-performance propellant, and it must be assumed that the problems of delivering large quantities of liquid oxygen to Woomera for use in the fully-developed North American engines enforced the development of what is probably the largest h.t.p. motor ever built.

The propulsion bay houses four separate rocket motors, a logical choice if only a small number of vehicles are to be built (one or two dozen have been discussed) since development costs are greatly reduced and, probably, the motors need to pivot in only one and not two planes. The four main service pipes running down the outside probably supply the pivoting rams with the gas used to pressurise the tanks. It appears that there are subsidiary motors to effect small changes in velocity after the main engines cease to burn, and these would presumably be the Armstrong Siddeley P.R.23. Further pipes from the extreme front of the cylindrical section may supply these vernier motors. The four fins, of flat chamfered section, are fixed. The front of the body has various detachable panels, so that access to the equipment may be possible without lifting off the nose section. There are a number of aerials on the fore part of the vehicle, and since the firing was a trial of radar communication it may be that a system of command guidance is under development. The launcher is not without interest: it appears that, logically enough, the weight of the complete vehicle is supported on the engine mounting rather than any part of the airframe. The vehicle is steadied by four swinging arms giving a zero-length action and counterbalanced to swing away from the body.

The Fairey "Fireflash" was exhibited but not flown: the interesting feature of the display was that three versions of the "dart" were shown, described as "fully operational," "all-weather," and "high altitude." The last, reasonably enough, had wings of increased area: the term "all-weather" suggests that aircraft are being developed in which the beam ridden by the missile is locked on to the target instead of being aimed at it by the pilot, but it was not possible to see any different receiving aerials on the example displayed.

Engines

A number of new or modified engines appeared, and more details than before were revealed of some previously known. In particular, nozzles more advanced than those hitherto seen in public were displayed, and some of them are illustrated on page 402. Certain of the power plants were illustrated last week; others not previously seen, at least in their present form, are mentioned here.



The "Black Knight" test vehicle has a typical cylindrical body and small stabilising aerofoils; the fin-tip nacelles contain flares and telemetry equipment. The actual vehicle is 35ft long

The Armstrong Siddeley P.181 and P.182 were the subject of an article on page 291, February 21, 1958, in which it was explained that these engines had a very compact annular reverse-flow combustion chamber. Our illustration shows this feature on the P.181; the ring main connecting the burners can clearly be seen. The P.182 now has its airscrew at the intake end, a variation made possible by the use of axial stages for the initial compression, and presents a rather unusual appearance, the spinner and the combustion chamber seeming to be the largest parts of the power unit.

A derivative of the "RB.108" jet-lift engine was shown by Rolls-Royce, Ltd. under the denomination "RB.145." As can be seen in our illustration, it has two main support points as if, like the vertical engine, it was intended to pivot. One of the two large igniter power packs can be seen; they supply igniters not diametrically opposite but close together in the combustion. A hint of the low compression ratio is given by the fact that the air bleed back to the intake for de-icing passes through what appears to be a plastic pipe. The auxiliaries, it will be seen, are driven off the front of the compressor.

This latter detail is also a feature of the "A.129," illustrated, derived, as was mentioned on page 434, March 21, 1958, from the existing Blackburn-Turbomeca range by the incorporation of a transonic two-stage low-pressure compressor. Exhibited was the "Turmo" derivative, expected to yield 840 h.p. initially and 950 h.p. when developed; also available, it was claimed, are variants of the "Palas" jet, the "Artouste," on which the intake centre-body would house reduction gearing, and the "Palouste" compressor.

In the display of electronic instrumentation and equipment, two main trends were to be detected. One showed the effort that is being made by the electronics industry to simplify the task of controlling the congested airways; the second showed the progress that has been made in reducing the size and weight of airborne equipment while increasing its resistance to mechanical damage.

Four-position display console (SD1000), a fixed coil display for radar systems

Air Traffic Control

With the rising speeds of jet aircraft and the growing volume of traffic in the larger airports, the responsibilities of Air Traffic Control for maintaining flight regularity with safety are becoming increasingly onerous. Indeed, the controller can only discharge his tasks with the assistance of mechanical and electronic aids of increasing complexity. One may envisage ultimately a fully-automatic computing system to replace the present procedural system of control. Some of the stages on the way to this goal have already been reached. For example, improved methods have been developed of presenting information by radar and of sifting and handling these data to lighten the controller's duties or, more correctly, to enable him to cope with an increasing volume of traffic.

Some of these developments were exceedingly well exemplified by Marconi's Wireless Telegraph Company, Ltd., who gave a comprehensive demonstration, using live radar signals, of some of the systems which are now available to assist the air traffic controller. Among these new aids are the provision of an easily interpreted synthetic radar display; an automatic tracking system; a future-position indicator; the superimposition of direction-finding on a radar display; and the use of closed-circuit television for presenting flight progress information simultaneously to several users. Besides these aids (any of which can be added to existing air traffic control centres), there was an impressive demonstration of a comprehensive system known as Civil Aviation Data Handling (CADH) which is being developed by the Marconi organisation. This system is based upon a memory track store which accepts information from radar, from aircraft in flight, and from adjoining control areas. The stored data from these sources is processed and presented to the controller upon demand, giving him a full picture of the air traffic situation in a readily assimilable form.

An outline of some of the equipments demonstrated follows here.

The airways control console is one of a series of fixed-coil displays, of which the "SD1000," illustrated here, is typical. This instrument provides a horizontal display with a 15in tube, and can accommodate four seated operators, each of whom can be equipped with individual strobe facilities. Its function is to show the controller only the aircraft under his control, eliminating other aircraft, clutter and permanent echoes. It does this by the use of a simple form of synthetic display. Instead of giving a first-hand P.P.I. (plan position indication) presentation, the display consists of symbols representing only the aircraft under control; the plan positions of these symbols are identical with those of the controlled aircraft on a normal P.P.I. and accurately keep to the same tracks.

In addition to the aircraft symbols, other inter-trace markers which are required can be displayed, together with ancillary information, such as the positions of ground beacons, and reporting points, which are added by the use of a video map. In this way the system provides tracking without distraction and, because of the nature of the data displayed, the picture can be very considerably brighter than the normal and so may be used in a greater ambient light. It therefore becomes feasible to use the synthetic display in the same desk as the flight progress board. A television camera ("BD871") is incorporated to give a picture of the controller's flight progress board. This picture is reproduced on monitor screens at the tracker's and approach controller's positions.

Another facility provided on the airways control console is the future position indicator, by means of an electronic (inter-trace) marker the controller is able to estimate the time of arrival of an aircraft at a given point. Alternatively, by setting a given time on a dial, the device indicates the position of the aircraft at that time, assuming that the aircraft keeps its present ground speed and track. In the demonstration the future position indicator (F.P.I.) was shown working on the synthetic P.P.I.

Further inter-trace markers were also provided on the P.P.I. displays to demonstrate a way of handing over aircraft from an airways controller to an approach controller.

The tracker's console, as demonstrated, contains a Marconi fixed-coil display unit "SD1010" and a television monitor. The radar display gives a normal M.T.I. (moving target indication) picture of approximately 100 miles radius, together with a video map. Inter-trace markers are also displayed; these are identical with those seen on the synthetic display in the airways approach console.

The tracking operator has to ensure that the marker symbols are initially placed on the correct aircraft (this is carried out by a joystick control) and that automatic tracking is maintained thereafter. The television monitor gives the tracking operator a picture of the controller's flight progress board and enables identity to be initially established.

Once a selected symbol is superimposed on an aircraft response on the P.P.I. display, a "Track-While-Scan" automatic tracking system takes over and maintains the symbol correctly positioned over the response, regardless of changes in speed or direction of the aircraft. A special protection circuit ensures that the system does not inadvertently "lock-on" to another aircraft which passes close to the wanted one. Indicator lamps show whether an aircraft track is "held" or "lost" and the tracking operator has instant access to any of the symbols under his control. Should the aircraft response fade from the display the system reverts to "Rate Aiding"—that is, the symbol continues to move in the same direction and at the same speed as given by the last responses. Any correction necessary is automatically applied when the response reappears.

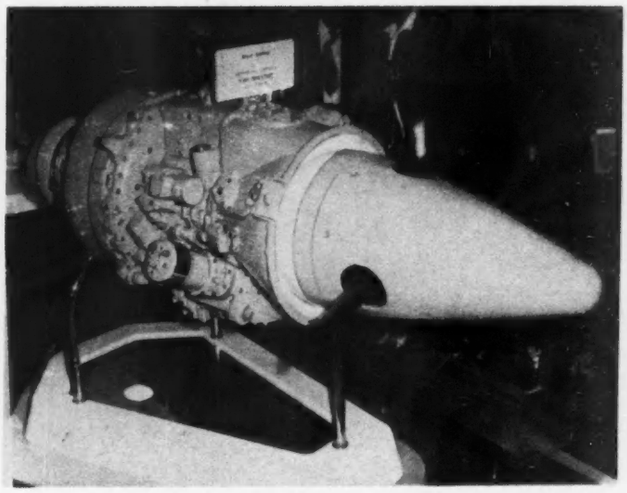
For the demonstration the display was limited to four "Track-While-Scan" symbols. Only one joystick control and five push buttons are used. The system can, of course, be easily enlarged to handle a much greater number of tracks.

The approach console contains a Marconi display unit "SD1010," together with a television monitor. The radar picture displays M.T.I. signals and is set up on a short range to enable an approach control operation to be carried out. The controller has a joystick-controlled interconsole marker with which he accepts aircraft handed to him by the airways controller; alternatively the console can be used for an outbound radar function, in which case the controller would hand aircraft over to the airways controller. The television monitor shows the airways controller's flight board and thereby visually supplies the approach controller with the additional information he requires.

The air traffic data handling system (CADH) referred to above represents a new approach to the problem of handling civil air traffic data. It provides a system of storing combined flight plan and radar information and presenting it concisely and unambiguously to the controller. Briefly, it provides the following facilities. (1) A synthetic plan position display. (2) An auxiliary display from which all relevant flight information on each track can be obtained. (3) A digital track store with a capacity up to 160 tracks, giving positional information on each track in terms of co-ordinates, co-ordinate velocities and height, and call-sign, route, destination, data. (4) Tracking facilities to enable tracks to be kept up to date from radar information, thus giving the present position of each aircraft with considerable accuracy. (5) Facilities for feeding information into the central store from other sources such as teleprinter link, DF, pilots' reports, &c.

The equipment consists of a desk control console incorporating the displays and

The " P.181 " shaft turbine delivers power at the exhaust end. The ring of burners in the annular reverse-flow chamber can be seen



The " P.182 " turbo-prop has an annular intake behind the spinner ; notice that the compressor casing is split through its axis

additional rack-mounted equipment according to the facilities required. The synthetic displays are plan-position cathode-ray tube displays showing two forms of picture, either of which is available to the controller at the flick of a switch. The first is a so-called " tadpole " display, where a bright dot indicates the position of an aircraft and a tail of somewhat lower brilliance indicates speed and direction. The second is a symbol display, the symbol indicating the present position of an aircraft and including various letters, figures and signs, indicating the track number (two letters) and height in thousands of feet (two figures with a dot to indicate 500ft, if necessary). A " tadpole " indicates climbing or descending, and a bar shows whether or not the information is derived from radar. In front of the controller is a knob calibrated in minutes, which enables him to advance the picture up to 7½ minutes into the future showing the anticipated state, assuming that present tracks will be maintained.

The controller can also draw the tracking supervisor's attention to any track.

Simultaneously, auxiliary information is shown on another cathode-ray tube display. It presents, in tabular form, the contents of four track stores, giving the aircraft call sign, route, destination, present height, requested height, estimated arrival time at reporting point, &c. The limitation to four such tracks is a matter of convenience and the system can be extended to cover customer requirements.

The digital track store is a central unit with a capacity for storing information on up to 160 tracks. It has write and read facilities from a tracking organisation working from fixed coil displays, so that plan position information may be fed in by trackers. It also contains associated computing machinery whereby the co-ordinate velocities can be calculated automatically and the present position information can be continually kept up to date by a rate-aiding process.

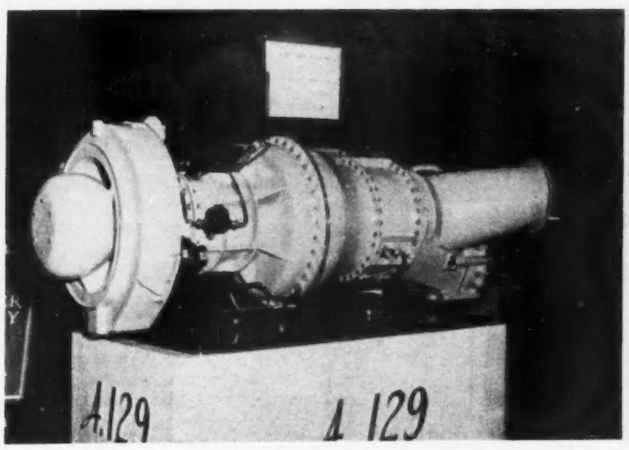
Ancillary information can be fed in by responsible officers by means of keyboards. Provision is also made for information to be written in from adjacent areas by means of teleprinter links. If air-to-ground data links are available, channelling can be provided for this also to be noted into the central store.

The tracking system is designed for five tracking groups, each consisting of a tracking supervisor and up to three trackers who have raw radar P.P.I. displays in front of them and are responsible for maintaining up-to-date track information on all aircraft under the control of the station.

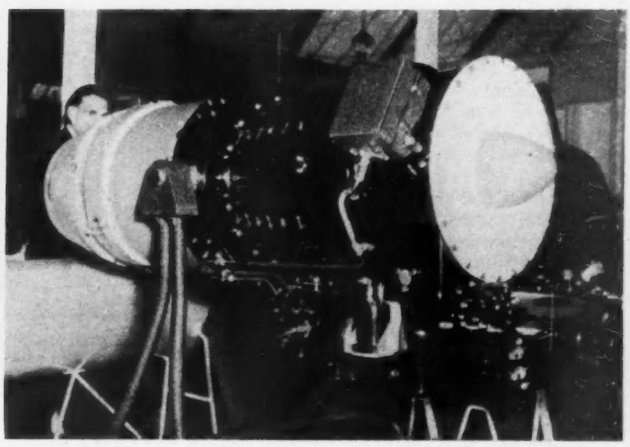
Track is started by the tracking supervisor by placing an electronically-generated ring marker over the P.P.I. response to be tracked and pressing the store button. This selects a vacant store and injects the position co-ordinates. The supervisor then waits until the next response appears and repeats the process of placing the marker over the response. This operation corrects the position co-ordinates and at the same time injects the co-ordinate differences in store. The store mechanism automatically notes the time interval between these two operations and effectively divides the co-ordinate differences by the time, thus producing a rate. This rate is used to correct the store position at intervals ensuring a continuous progression of the track. The supervisor then uses a press-button mechanism to hand over the store to one of his three trackers.

The tracker normally operates on the stores allocated to him sequentially ; at any one time he will have before him on the P.P.I. a ring marker indicating the present position of a track. If it is necessary to correct it, he then encircles the radar response and presses his store button which feeds the necessary corrections into the storage system and automatically selects the next track store in his sequence. In the case of a store which does not require correction, he can press the store button without engaging his joystick control. In the case of tracking difficulties the tracker can hand back the store to the supervisor for his action.

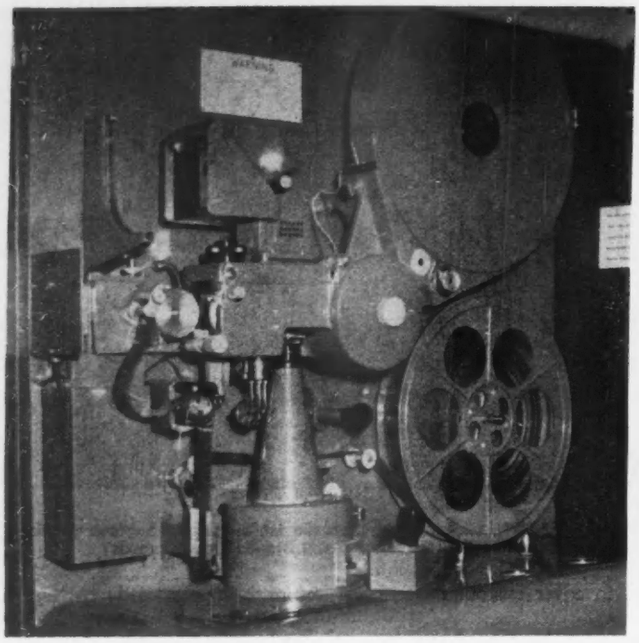
The supervisor is also responsible for identification. Height will generally be taken from pilot report and information can be injected into the central storage system from other sources.

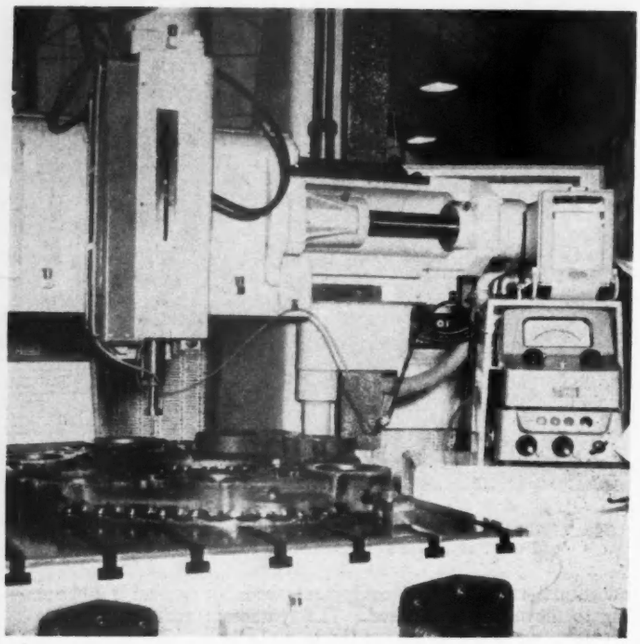


The " A.129 " is seen here in free-turbine form ; its low-pressure compressor has two axial transonic stages



The " RB.145 " engine is derived from small lifting jets. It has a thrust of 2750 lb





(Left) A rapid processing projector, showing, from right to left, the camera looking down upon a c.r.t., the processing station fed with chemicals, and the projector directed upward on to a reflector. Used film is stored on a reel. (Right) This computer-controlled jig borer is equipped for the automatic measuring and recording of dimensional errors

Civil Aviation Radar

The radar signals to the air traffic control display described above were obtained from an "S264" equipment which is an airway control radar intended for use in the regulation of aircraft approaches and departures from the airport area. It has been developed from the "S232" radar now operating at London Airport and elsewhere; the horizontal beam width has been reduced to about 2¼ deg. measured at −3 dB points, one way, and the range has been increased.

The aerial system consists of a reflector 52ft 6in long by 12ft high, built up of horizontal rods of aluminium alloy spaced 4½in apart. The radiator is a linear slotted waveguide with a rodded flare. An air-spaced coaxial feeder is used, together with a capacitive rotating joint. The whole aerial system can be tilted from −1 deg. to +10 deg. in elevation. A two-speed drive (5 or 10 r.p.m.) is obtained, through epicyclic gearing, from two 30 h.p. slipring induction motors, the gear change being effected electro-hydraulically under remote control.

Crystal-controlled operation is obtained on any eleven-spot frequencies between 585 and 610 Mc/s, with a peak power output of 50kW to 60kW, a pulse recurrence frequency of 525 to 775 p.p.s., and a pulse length of 2 or 4 microseconds.

A Marconi storm detection radar "SNW51" was also demonstrated. It operates in the X band (9360–9460 Mc/s) and is designed to give a plan picture showing the location of storms and rain clouds at ranges up to 200 nautical miles. It has a peak power output of 40kW from a high-gain tiltable aerial with power-operated tilting and tell-back facility remotely controlled from the main display. The scanner is designed for operation in 60-knot gales and 120-knot gusts, rotational speeds of 7, 10, 14 or 21 r.p.m. being obtainable from a 3 h.p. motor. The aerial, illustrated here, is a section of parabolic cylinder fed by a length of waveguide having shunt-inclined slots in one of its narrow faces, mounted in a flared horn.

The pulse repetition frequency is 350 p.p.s. and the pulse length 2 microseconds. The specified range accuracy is 1 per cent of the range in use (40, 100, 150 or 200 nautical miles) and the bearing accuracy is given as less than ½ deg.

Applications of radar to civil aviation were also demonstrated by Decca Radar, Ltd., Albert Embankment, London, S.E.1. This company is very conscious of the fact that the use of higher power, longer range, radar equipment is complicating the task of handling radar information in air traffic control organisations. Much of this firm's development effort stems from the appreciation that properly planned display systems, sifting and integrating information from more than one radar, where necessary, are becoming urgent, particularly where traffic densities have already reached high levels. The Decca "Interscan" display system is specially designed for this class of operations room, because other facilities besides radar information can be generated and displayed electronically to help the controller. These facilities include runway extension markers, geographical markers showing the position of beacons, symbols for marking particular aircraft echoes, and means of giving accurate position fixes to aircraft in relation to any point on the radar display.

Aerial head of storm detection radar

An interesting new equipment is the "D.A.S.R. 1" long-range civil surveillance radar, specially developed by Decca for terminal use where high speed, high altitude, civil aircraft are being operated. It has a coverage extending above 40,000ft and ranges well in excess of 100 miles. Operating in the 10cm band, this single equipment not only provides long and close coverage, from the radar horizon to well above the present limit of aircraft operating heights, but also has a high rotation rate and a narrow beam width, to provide a radar picture suitable for controlling aircraft accurately even at long range. Modern techniques, such as variable polarisation to eliminate weather echoes and air-target-indication to suppress permanent ground echoes, are built into this radar. The use of separate transmitters feeding a double-reflector, back-to-back aerial array is another interesting detail in design and it is this technique which allows the high performance to be extracted from a comparatively small radar station.

Computing Equipment

As we have indicated above, the growing density of air traffic is likely to encourage the eventual development towards automatic traffic control with the help of computers. Although this stage has yet to be reached, control and calculating instruments were well represented in the static exhibition.

There was, for example, the "E.B.20" automatic flight control system, made by Elliott Brothers (London), Ltd., under licence from the Bendix Aviation Corporation of America. This instrument utilises proportional displacement-plus-rate signals to provide, by electromechanical computation, precision control for high-performance turbo-jet and turbo-prop aircraft. The control forces it exerts on the aircraft are accurately

proportioned to air speed and altitude: gyroscopic rate control is used on all three axes; computing and satisfaction of deviation signals are achieved through electro-mechanical integration; and aircraft manœuvring while automatic control is engaged can be accomplished through a console-mounted controller or by control-stick steering, as selected by the operator.

Displacement-plus-rate control is used to ensure that deviations from flight path are held to small values. Since displacement signals are recognised and corrections are applied for small deviations, the control forces required are lower than those necessary for manual flight conditions. This refinement results in a higher accuracy of flight path, eliminates severe strains on aircraft structure, and assures greater passenger comfort. Flight equilibrium under cruise conditions is accurately and continuously held: airspeed, altitude or other control references can be constantly monitored; there is automatic cross-wind adjustment, and descent on the glide slope is carefully regulated, both for accuracy and maximum safety.

Electro-mechanical computing is used extensively with identical servo-loop design and standardised plug-in units. Amplifiers are of card type modular design and make use of silicon transistors and miniature magnetic amplifiers.

This company has also developed a miniature computing system, for installation in an aircraft to supply continuous information about the atmosphere through which it is flying. Basic data are obtained from static, pitot-static and temperature transducers, signals from which are supplied to the transistor and magnetic amplifiers of the computer. By the use of differentials, cams and servo-operated gearboxes, they are transformed to the desired outputs which are fed to the presentation units, "autopilot," or other equipment requiring the information. Various outputs are available, including indicated air speed, Mach number, height, rate of climb and true air speed. If all these quantities are not required, it is often possible to omit the appropriate gearbox so that overall size, weight and cost are reduced. The computer has provision for position error correction as a function of Mach number introduced to pitot and static transducers.

At the other end of the scale of calculating instruments is a small analogue computer known as the "Minispace" designed and made by the Solartron Electronic Group, Ltd., Thames Ditton, Surrey. It is a self-contained computer consisting of ten drift-corrected d.c. amplifiers with the requisite input and feedback components, potentiometers, control and patching panels and power supplies. Non-linear elements are incorporated and provision is made for expanding the computer. The whole equipment is contained in a cabinet 51in (127cm) high, 20in (51cm) wide and 30in (76cm) deep. The high-stability power supplies, giving a total of 400mA at $\pm$300V, are mounted below desk level. Space is provided for the addition of the Solartron TJ725 servo-multiplier.

Each of the ten amplifiers can be used for summing, sign reversing, integration or the simulation of a transfer function over a wide range. Thus any problem requiring up to ten such operations can be solved or simulated: for example, two simultaneous second or third order differential equations or one equation of the fourth or fifth order. With the Solartron TJ725 servo-multiplier, for which space is provided, the "Minispace" can be used as a multiplier, resolver, or non-linear function generator for many more complex problems. Two "Minispaces" can be coupled together and operated from the control panel of one, thus making a twenty-amplifier installation, or two ten-amplifier units with own control panels, as required.

All the computing elements are permanently wired, connections to them being made on the patching panel. Amplifiers are each committed to sum or integrate by switches on the patching panel. Each amplifier position has four summing inputs (two $\times$1 and two $\times$10 gain), and either 1μF or 0·1μF (0·5 per cent tolerance) polystyrene capacitors for integration associated with it. The fixed input and feedback resistors are wirewound, 0·1 per cent tolerance. Twenty wirewound, ten-turn, helical potentiometers are provided for non-integral transfers, initial conditions and transfer functions of the form $1/1+pT$. More complex series or parallel feedback networks are easily introduced by removing link plugs on the patching panel. Four earth-free potentiometers and four diodes are provided for the simulation of non-linear functions such as dead zone, limiting or backlash.

A dual-purpose, centre-zero meter on control panel monitors the supply or output voltages or acts as a balance indicator (three sensitivity ranges) for setting coefficient potentiometers against the reference potentiometer, for which purpose a $\pm$100V reference supply (0·2 per cent) and a ten-turn direct reading helical potentiometer (0·1 per cent linearity) are incorporated. Though designed as a real time computer an incorporated repetitive switch enables "compute" periods of one, two and five seconds with a one-second reset period, to be obtained automatically with a trigger signal. A central overload indicator is fitted. A normal long-persistance oscilloscope can be used for display.

Four computer control positions are incorporated for "potentiometer set," "problem check," "compute" and "hold" facilities, which are done by internal relays. At "potentiometer set" all potentiometer transfers and integrator initial conditions are established. On "problem check" (static) the initial conditions on integrators are retained; but all summing amplifiers operate as on "compute." For the accurate setting of a transfer or initial condition it is only necessary to set the reference potentiometer at the value required, depress the key switch associated with the coefficient potentiometer, and adjust this until the meter indicates balance.

There was also demonstrated in conjunction with the radar which has an aerial speed of 10 r.p.m., (page 406) the Kelvin Hughes rapid processing film projector. This exposes a film during one sweep of the p.p.i., develops and fixes it during the next, and projects it on to a screen twelve seconds after it was taken. This allows a much larger picture to be obtained than by direct projection from a cathode-ray tube, and also gives a permanent record of the information presented. Three of these projectors have been installed by the C.A.A. at its Technical Development Centre, Indianapolis, overlapping plots of two radar stations 50 miles apart being projected on a common screen.

A specially-developed Ilford 35mm film is used, packed in cassettes in lengths up to 2000ft; approximately 2in is needed for each exposure. The film passes over three apertures: in the first it is exposed by a drum shutter to the face of a 7in c.r.t. through a camera lens system; in the second it is sprayed with developer, bleach, fixer, wash solution and warm air; in the third it is projected by a mercury-xenon arc lamp. To prevent light or liquid leaking along the film from one station to the next, the film is kinked between exposures by a mechanical crimper. The cycle time of six seconds is the minimum for records of archival quality on negative processing film; for positive processing between fifteen seconds and one minute is required. The apparatus is air driven, and dry oil-free air must be supplied at 25 lb to 30 lb per square inch. The unit is capable of both front and rear projection, and will normally be installed in pairs with a common changeover mirror to ensure continuity in service.

Static Exhibition

Included in the static exhibition were, of course, many of the engines and model aircraft, and other items which have been described separately. Some of the exhibits of engineering interest are described briefly here.

Metachemical Processes, Ltd., Crawley, Sussex, display what are called "electroforms" in "Micrograin" nickel; these possess extreme erosion resistance, and have resisted a simulated rainfall of 3in per hour at 500 m.p.h. for thirty-five hours without loss of weight. The "electroforms" take the form of a thin sheath and can be formed on any shaped solid from which it is possible to remove them after deposition, e.g. a cylinder but not a sphere. The process involves coating a mandrel with a conductive thermoplastic, an import from Germany, copper plating and then electroplating in a conventional nickel sulphate bath. Whereas a deposit on a metal electrode will tend to have a crystal size similar to that of the electrode, the growth in this case has a grain size of the order of 1 micron, at least for the first few mils. As is expected with electrodeposits, the thickness tends to increase with curvature, which is particularly convenient when making sheaths for the electric de-icing elements of propeller blades. The hardness diminishes towards the surface, a typical variation being from 510 V.P.N. to 485 V.P.N. in 0·020in; the hardness can be varied by control of the grain size up to 700 V.P.N. The mechanical strength of the electroform is, on a sample of V.P.N. 450, 135,000 lb per square inch w.t.s. across the grain, the corresponding elongation being 4·5 per cent.

On the Ministry of Supply stand there was demonstrated the automatic inspection project of the Inspectorate of Electrical and Mechanical Equipment. This is basically a Bryant Symonds jig borer converted to the tape-controlled Ferranti machine tool control system with the feed mechanisms replaced by lead screws and recirculating ball nuts manufactured by the Coventry Gauge and Tool Company, Ltd. The modified machine will, it was shown to us, reproduce movements within 0·0001in and, in the far from temperature-controlled exhibition, was accurate within 0·0005in. Deviations between the head movement and the surface followed were amplified electrically by the apparatus on the right in our illustration and presented continuously on a Southern Instruments "Magna-Gage" and recorded on a paper trace. The inspection machine cannot accept the same tape as was used to command the machining of a component; tapes for each component are prepared by Ferranti, Ltd.

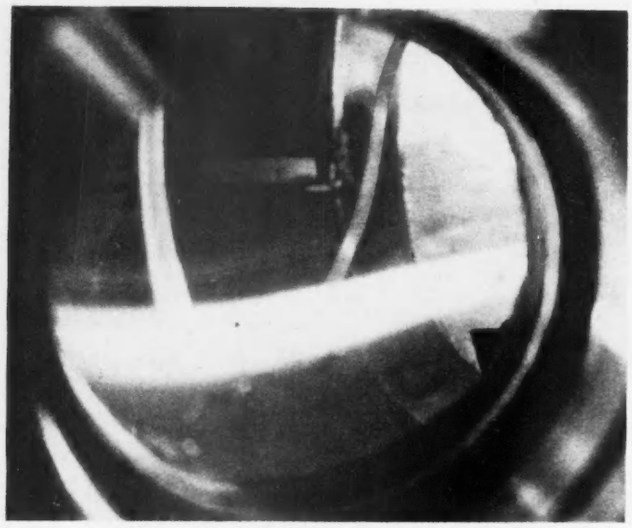
(*To be continued*)

Frameless Aluminium Buildings.—The Coseley Engineering Company, Ltd., announces that it has acquired the world rights to manufacture and market "Kingstrand" frameless aluminium buildings. This system was developed by Aluminium Laboratories, Ltd., Kingston, Canada.

Conference on "Atoms for Peace"

No. I

About 5000 representatives have been conferring in Geneva on the peaceful uses of atomic energy. This has been the second such international conference arranged by UNO (the first was in 1955); it began on September 1 and will end on September 13. More than 2200 papers have been submitted and we reproduce below abstracts from a number of them. The illustration alongside shows an intense d.c. carbon arc running the length of the Oak Ridge National Laboratory thermonuclear experimental machine. Molecular ions passing through the arc are broken into atomic ions. The latter are held by a magnetic field and circulate in a glowing ring as seen here through a side window.



IN seventy-seven sessions at the Palais des Nations, Geneva, about 5000 representatives from nearly seventy countries have been taking part in the second international conference of the United Nations on the peaceful uses of atomic energy. Over 2200 scientific papers have been submitted, 650 of them being presented orally. It was expected at the beginning of the conference that the proceedings would fill thirty-three volumes (the first conference, in 1955, required sixteen). Publication will begin soon after the conference ends; completion is expected by June, 1959. Clearly a conference on this scale cannot be reported here in more than summary form, so we have selected a number of papers interesting to engineers. Abstracts from these are reproduced below.

On the day before the conference began* it was announced jointly by Sir John Cockcroft, chairman of the U.K. delegation, and Lewis L. Strauss, chairman of the American delegation, that their two countries had "declassified" the work they were doing on the control of thermonuclear reactions; this would free the international exchange of information so far as the U.K. and the U.S. were concerned, The Russian delegation subsequently presented, "as a gift to the conference," a collection of papers on thermonuclear research in the Soviet Union up to this year. The four volumes† were produced at the end of the reading of the first Russian paper. Taxed at a subsequent Press conference, however, the Russian delegate would not say that future work would be "declassified" in the same way as the British and American research. Several delegates expressed hopes during the conference that international collaboration in this field would follow, however.

Controlled Thermonuclear Fusion

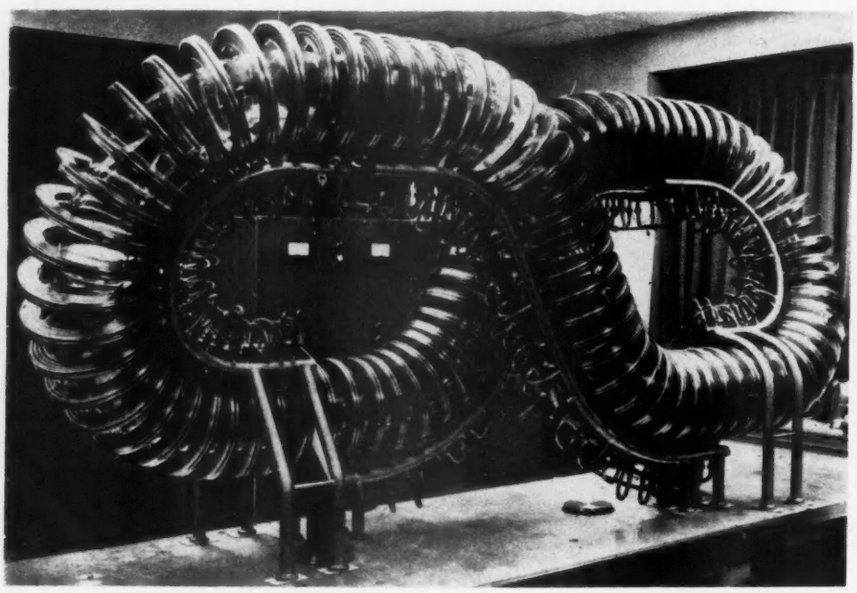
Controlled Thermonuclear Research in the United Kingdom. By P. C. Thonemann (U.K.).—The British research programme is described, and the reasons for concentrating on the "pinching" method of containment are stated. A brief history is given, the problems to be solved are categorised and exemplified, and the prospects are indicated.

Peaceful Uses of Fusion. By Edward Teller (U.S.A.).—The development of the American programme along several lines is explained. The four approaches referred to are: (i) closed annular pulsed currents encircled by magnetic fields (the "pinch" effect); (ii) the "Stellarator," which aims at a steady state; (iii) machines with open-ended fields which are more intense in two places and act as magnetic mirrors there, and (iv) circulating relativistic electrons establishing a closed pattern of magnetic lines within which the ionised gas is confined. The difficulties are stated to have been proved considerable, but economic production of power is believed to be feasible in the future. It is suggested that fusion energy may be brought into practical use sooner in the form of controlled explosions.

Investigations on the Controlled Thermonuclear Reaction in the U.S.S.R. By Z. A. Artzimovich (U.S.S.R.).—The principal directions followed are stated to have been (i) development of methods of heating to very high temperatures in powerful pulsed electromagnetic processes, (ii) investigation of methods of heating plasma in quasi-stationary high-current discharges, and (iii) investigation of methods of heating and containing plasma in magnetic "traps." The main data from experimental and theoretic investigations are analysed, and a criterion by which to choose the principle of a thermonuclear generator is presented.

Gas-Cooled Reactors

Operating Experiences at Calder Hall. By H. G. Davey, J. Gawthrop and T. N. Marsham (U.K.).—The operation of the control system and the degree of flexibility available are described, and various limitations are mentioned. The performance and adequacy of important equipment such as instruments and safety circuits, fuel handling gear and burst slug detectors are discussed. It is concluded from the experience of eighteen months' operation that the reactors are reliable and flexible enough to be well suited for electrical generation.



A demonstration model, part of the U.S. fusion exhibit at the Geneva Conference, which shows the magnetic field pattern of a "figure-eight" shaped "Stellarator." This novel shape permits a strong magnetic field to serve as a "magnetic bottle" for hot, ionised gas. Princeton University, Princeton, New Jersey, U.S.A.

* The conference started on Monday, September 1 and finishes to-morrow, Saturday, September 13.

† According to the Russian delegation's description the works are in chronological order. The first volume starts with a detailed study of the thermal insulation of plasma by the magnetic field of a straight solenoid: the necessity for an axial current in a torus is pointed out. The remainder of the volume deals mainly with systems using the "pinch" effect. The second volume is devoted largely to investigation of the latter, both in theory and experiment. The third volume indicates increased interest in other methods of collecting and heating plasma, including the use of magnetic mirrors. The most recent work, in which the physics of plasma is particularly dwelt upon, is reported in the fourth volume.

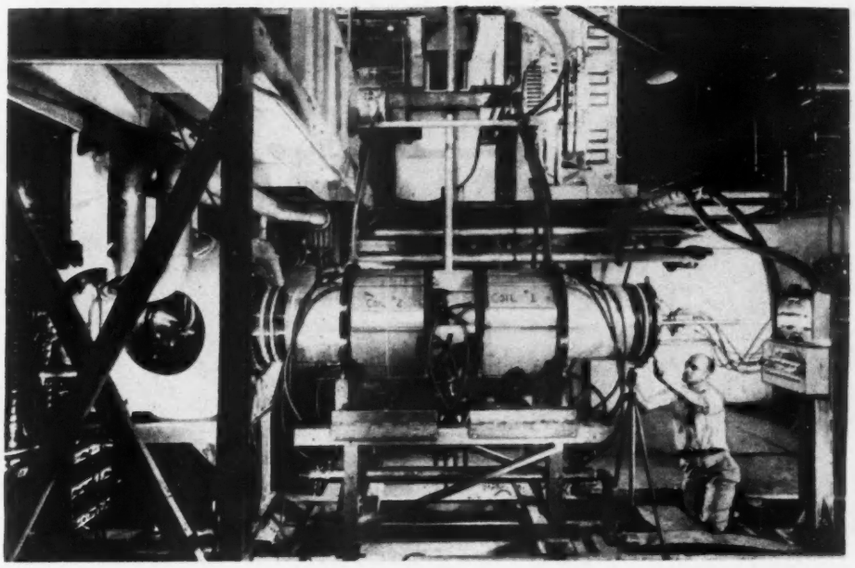
Safety Aspects of the Calder Hall Type Reactor in Theory and Experiment. By G. Brown, J. Moore, H. Kronberger, P. W. Mummery and F. M. Leslie (U.K.).—The nuclear and thermal kinetics of these reactors are examined, and relevant experiments are described. The results of compatibility studies are outlined, and the effects of irradiation on fuel elements, graphite, and constructional steel are mentioned. Some hypothetical faults are considered, e.g. loss of control of reactivity, failure of blowers and loss of pressure.

General Review of Graphite Moderated Thermal Reactor Calculations. By C. G. Campbell, B. Cutts, I. A. Mossop and P. W. Mummery (U.K.).—The Calder Hall reactors were designed by a method which had been correlated with integral experiments, but tests on the first reactor showed discrepancies between prediction and performance. The method of calculation used for Calder Hall is given together with the correlation with integral experiments, and explanations are suggested for the discrepancies. The difficulties of calculation when plutonium is present are alluded to, and a proposal is outlined for a system of lattice calculation needing a new correlation with integral experiments.

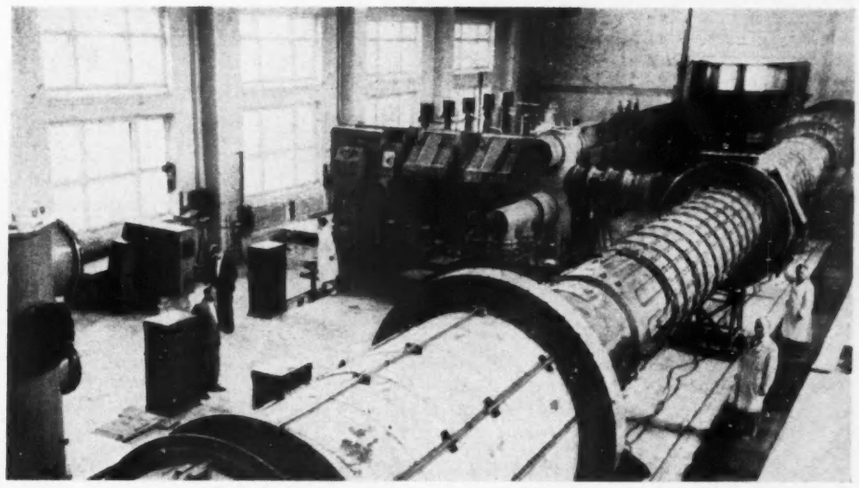
Derivation of Reactor Heat Transfer Transient Equations for Gas-Cooled Graphite Moderated Thermal Reactors. By T. J. O'Neill (U.K.).—The inputs for these equations are reactor power, gas flow, and inlet gas temperature. The outputs are outlet gas temperature, uranium and graphite variables that affect reactivity and maximum fuel element temperatures. The derivation of such equations is considered. Partial differential equations for the system are obtained from consideration of a unit length of channel. Spatial integration leads to a form suitable for analogue computation. The final equations are given for a solid-block type of moderator and for a moderator involving in part a graphite supporting-sleeve for a fuel element. Conductive, convective and radiant heat transfer are taken into account.

Advances in the Design of Gas-Cooled Power Reactors. By R. V. Moore, L. Grainger and H. Kronberger (U.K.).—The main engineering features and economics of reactors improving on Calder Hall are considered. There is discussion of the effects of fuel rating, burn-up, fuel cycles, new canning materials, ceramic fuel elements, the stability and life of the moderator, and safe running with plutonium-rich fuel. The U.K.A.E.A's advanced gas-cooled reactor project is briefly described, and it is held that the 1965 nuclear power stations should produce power more cheaply than coal-burning stations, with a performance probably unexcelled by any other operational reactors.

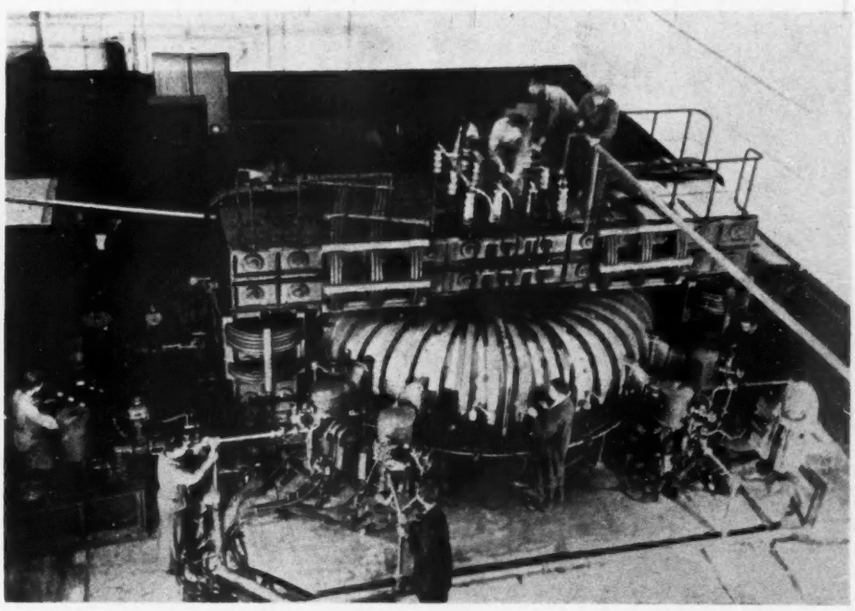
The Possibilities of Achieving High Temperatures in a Gas-Cooled Reactor. By L. R. Shepherd (U.K.).—The heat-output density of large gas-cooled reactors burning natural uranium is limited, and the maximum coolant temperature at the outlet is also limited. Compact reactors with power densities as high as those of pressurised water reactors are desirable, though not with the coolant temperature limitations of either the pressurised water reactor or the more advanced natural-uranium gas-cooled systems. Coolant outlet temperatures well above 650 deg. Cent. are needed to exploit modern turbo-generators, and 750 deg. Cent. is desirable for gas turbines or mixed turbines (gas and steam). A high-temperature gas-



Experimental "mirror" machine designed for experiments in trapping injected high-energy particles by a time using magnetic field. The magnetic field is generated by a 10^9 joule condenser bank which is discharged through the coils. University of California Radiation Laboratory, Livermore and Berkeley, California, U.S.A.



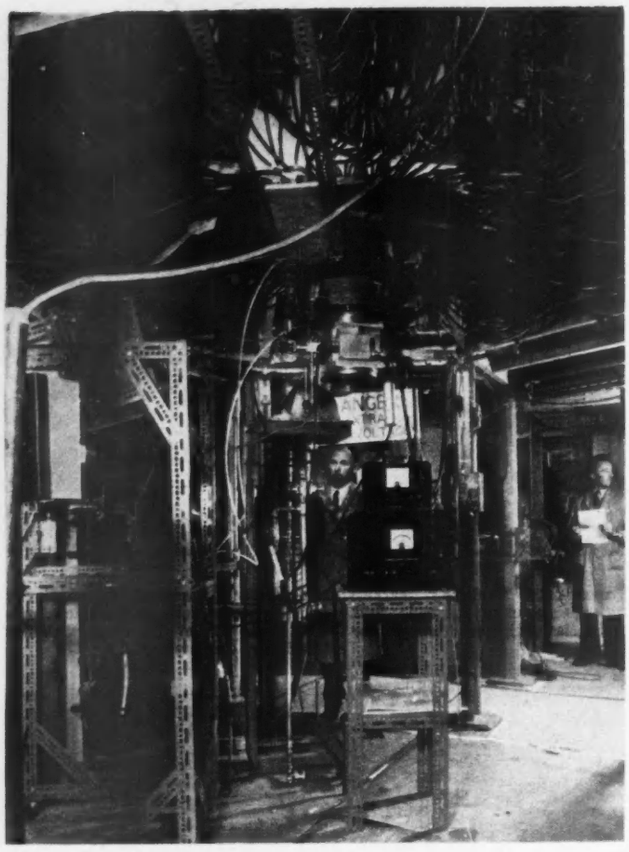
Linear thermonuclear experimental machine "Ogra." U.S.S.R.



The Russian thermonuclear experimental machine "Alpha," which corresponds to the British "Zeta"

cooled reactor is being considered for running on enriched fuel incorporated in a solid moderator to give a greatly extended heat-transferring surface and permit a high density of heat output. Core materials are in highly refractory form and metallic cans are avoided.

The Economics of Enrichment and of the Use of Plutonium and Uranium 233. By N. L. Franklin, J. M. Hill, C. A. Rennie and J. C. C. Stewart (U.K.).—The cost of power from a gas-cooled reactor burning metallic natural uranium is analysed briefly. The effects of the fuel cycle and the size of the reactor on reactivity are discussed, and the cost of power with burning of enriched uranium is then considered. The uses of enrichment to modify operating characteristics or output are examined, and the economics of these uses reviewed. The general principles of the use of plutonium instead of U^{235} are considered for the cases of complete plutonium recycling and plutonium/natural uranium fuels. Systems based on these principles are compared with systems using uranium enriched in U^{236}, and the relative economic worth of enrichment with plutonium and U^{235} is estimated. U^{233} is considered as a fuel, and its short-term cost is shown to be high ; it is thought to be unsuitable for the present designs of gas-cooled reactor.



Fusion work at A.W.R.E., Aldermaston. The 45,000 joule condenser assembly showing the discharge tube and some of the wiring

Design Study for a Graphite-Moderated Gas-Cooled Reactor Using Partially Enriched Uranium. By R. A. Charpie, W. H. Jordan, A. P. Fraas, A. M. Perry and R. D. Schultheiss (U.S.A.).—The outstanding British success with large graphite-moderated gas-cooled reactors is said to have raised the question of the place for this type in the U.S.A. The advantages and disadvantages of the system are reviewed, and the possibility of using helium and enriched uranium in the U.S. is considered. Costs are examined generally and in detail, and the design of a minimum-cost reactor is discussed. Various fuel element designs and materials are considered.

A view of "Zeta" (zero energy thermonuclear assembly), the Harwell apparatus in which experiments towards controlling fusion have resulted in temperatures originally estimated at 5,000,000 deg. Cent. being achieved for millisecond periods. The transformer windings and the torus can be seen

Pressurised Water Reactors

Theoretical and Experimental Work on Heat Transfer and Fluid Flow Characteristics of Pressurised Water Reactors. By W. H. Esselman, S. J. Green and P. C. Ostergaard (U.S.A.).—Starting with the design criteria prohibiting steady local boiling and transient bulk boiling, the uncertainties which resulted in these limitations are identified and reduced using the results of experimental and analytic work. The basic thermal design limitation is given as the prevention of local fuel temperatures critical with respect to physical and corrosion-resisting properties. Tests are analysed to develop better theoretic understanding of pressure drop, flow, heat transfer, and transition boiling performance. Design equations are derived. Observed performance is compared with predictions from these equations.

Heavy Water Moderated Power Reactors. By D. F. Babcock (U.S.A.).—Methods of getting useful power from reactors burning natural uranium in a heavy water moderator are being studied. The study is based on experience in the last five years in operating plutonium-producing reactors at the Savannah River plant, together with development under the power reactor programme. The basic type of reactor chosen for investigation employs a tank 40ft long by 12ft inside diameter, working under 1000 lb per square inch. Heavy water would rise in the tank, pass through the fuel assemblies down and out to a heat exchanger, and return to the reactor. Expected operating parameters when this reactor is putting out 100MW of electrical power are given in the paper, and the scheme is compared with other kinds of reactor such as those cooled by gas, those using pressure tubes instead of a shell, and those burning oxide fuel. Particular attention is reported to have been paid to developing the fuel element. The current model is a 2in diameter tube with an inside diameter of $1\frac{1}{2}$in. It is 15ft long and clad in "Zircalloy 2" by extrusion ; the interior is of 2 per cent zirconium-uranium alloy. Tests on such tubes are described, and the method is compared with that of using an oxide element.

Experiences in the Design, Construction and Operation of the Pressurised Water Reactor Power Plant at Shippingport. By J. W. Simpson and H. G. Rickover (U.S.A.).—The conception of the plant is described, and the considerations of physics, metallurgy and chemistry that influenced design are enumerated. Waste disposal and fuel handling systems are described as among the many problems encountered, and the solutions are thought to be of general interest. Predicted performance and test results are compared.

The Canadian NPD-2 Nuclear Power Station. By I. N. MacKay (Canada).—This project was begun early in 1955. The objects include demonstration of the practicability of the type in Ontario. The net electrical output is to be about 20MW fed into the Ontario hydro-electric network at des

Joachims. Natural uranium fuel is burnt in the form of sintered dioxide, heavy water moderating and cooling the reactor. Horizontal tubes of zirconium alloy contain the fuel and the pressurised coolant. The reactor vessel is of aluminium alloy and contains the moderator at about atmospheric pressure ; the double walls contain ordinary water for reflecting and shielding. Water leaves the reactor at 277 deg. Cent. and about 1000 lb per square inch, being cooled to 252 deg. Cent. by a heat exchanger which raises dry saturated steam at 425 lb per square inch. There are three pumps, with flywheels to prevent boiling if power fails. Various forms of fuel are to be used. Two machines permit replacement of individual slugs under full load. Each slug is fully irradiated on discharge. Adjacent channels are loaded from opposite ends to keep the flux distribution approximately symmetric. Control is entirely by movement of the moderator level, i.e. by regulating the difference in helium pressure between the calandria and the heavy-water storage tank. The steam pressure is held constant at the turbine throttle. Starting and load changing are automatic, but the rate is limited by the operator. In emergency the helium pressure difference virtually disappears, and the moderator falls through three pipes into the storage tank. The scope of this kind of reactor is discussed in the paper, and costs are estimated.

Self-Regulation in Pressurised Water Power Reactor. By V. A. Sidorenko (U.S.S.R.).—The paper investigates various transient processes caused by variations of external load and of working conditions in the circulatory system. With a rather high negative temperature coefficient of reactivity it is possible to operate plant reliably without special external regulation.

Pressure Water Reactors in the U.S.S.R. By S. A. Skvortsov *et al.* (U.S.S.R.).—A number of power stations in the Soviet Union are to use ordinary water for moderation and cooling. The paper outlines briefly the considerations in selecting parameters. Water cooling cannot provide superheated steam at high temperature and pressure. Comparison of thermal efficiency when using superheated steam at low pressure with thermal efficiency when using saturated steam at medium pressure leads to results favouring the latter. A considerable rise in the pressure of saturated steam proved inadvisable. The prospects of future construction of such power reactors are mentioned.

(*To be continued*)

Swedish Uranium Extraction

PLANS for a uranium extraction plant using native schist deposits from Mount Billingen, in South West Sweden, have reached the blueprint stage, according to AB Atomenergi. The plant—to be called the Ranstad Works—is to produce 120 tons of uranium per annum from 900,000 tons of crude schist.

The plant is to include crushing and sorting works, a lixiviation plant, refinery, office and service buildings. The total cost is estimated at Kr.115 million (£7,930,000), with an additional Kr.10,000,000 for the refinery.

The schist contains deposits of a special kind of calcareous rock, which is separated during the production process. It will be used for neutralising the waste solutions from the lixiviation plant. The refined ore contains about 320 grammes of uranium per ton.

The shale remainder of the schist retains its structure and its fuel value through the lixiviation process. This waste product has a fuel value corresponding to that of 500 tons of coal per day.

Design Data for Flat Air Bearings Under Steady Load Conditions

By H. L. WUNSCH, M.Eng., A.M.I.Mech.E.

While air bearings have been used for a variety of purposes, both in the laboratory and also, to some extent, in industry, there is a definite lack of published information necessary for their systematic design. In other words, whilst it is not too difficult to design an air bearing for a particular purpose and to make it work, it is by no means so easy to get the optimum design from the point of view of maximum stiffness, maximum load and economic air flow.

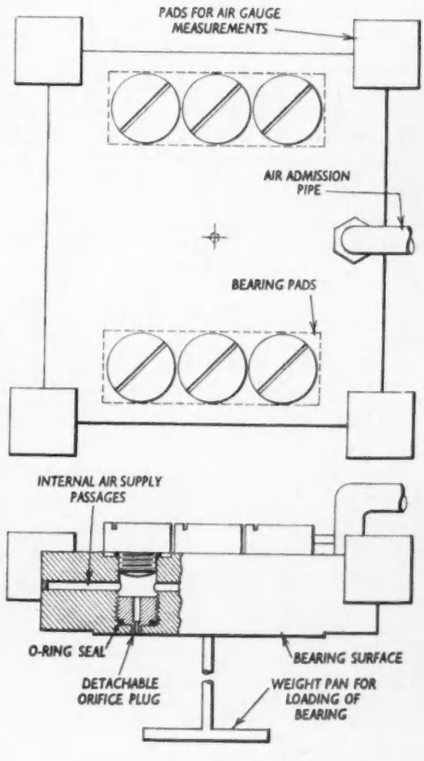
AN order to provide design information for at least one form of air bearing, a fundamental investigation is being carried out. As a first step towards this, tests have been carried out on a flat air bearing, of the type shown in Figs. 1 (*a*) and (*b*), to determine the relationship between certain design parameters, such as bearing area, orifice diameter, bearing lift and load. These tests have been confined to two geometrically similar bearings of different bearing area and the results obtained are only valid for bearings geometrically similar to the ones tested.

An analysis of the results has been carried out and empirical equations relating orifice diameter bearing area, bearing lift, load and stiffness for a supply pressure of 40 lb per square inch have been obtained. A design example is given in an appendix to the paper to indicate how these results can be used in practice.

CONSTRUCTION OF EXPERIMENTAL EQUIPMENT

Two sizes of bearings have been used ; the first one has two equal pads, each 4½in by 1½in (i.e. 13½ square inches), with three air admission holes in each pad spaced along the centre line and with 1½in between each hole. The second bearing, which is geometrically similar to the first one, has two pads each 3in by 1in (i.e. 6 square inches), with three air admission holes in each pad spaced 1in apart. As will be seen in Fig. 1 (*a*), the air admission holes in each bearing are drilled in detachable plugs, so that various orifice diameters can be tested, while at the same time the outlet of the orifice can be arranged to be either flush with the bearing surface or set back from it by any desired amount. This set-back is accurately set by means of a 1/10000in dial indicator with a pointed stylus, which can be placed on the orifice plug and bearing surface alternately.

The air is admitted to the bearings at one point and distributed to the six orifices by means of internal manifolds. The bearing surfaces are ground and lapped to obtain a high degree of flatness and the bearing floats on a base which is similarly finished. Pegs on this base prevent the bearing moving more than about ¼in in the horizontal plane.



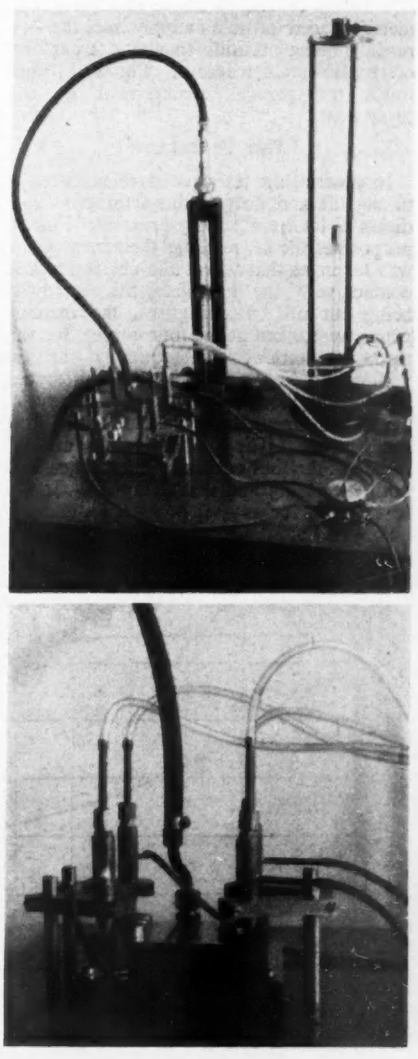


Fig. 1—Experimental equipment for testing air bearings

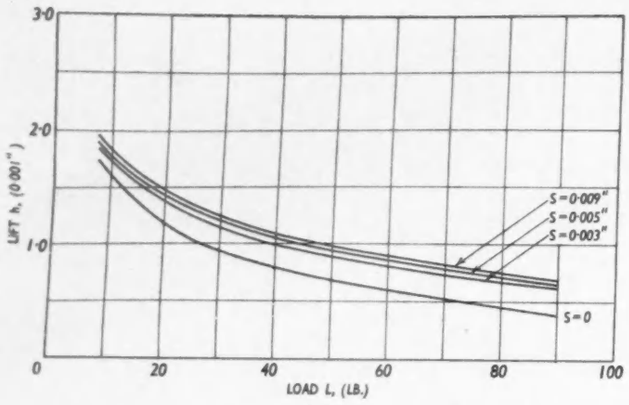


Fig. 2

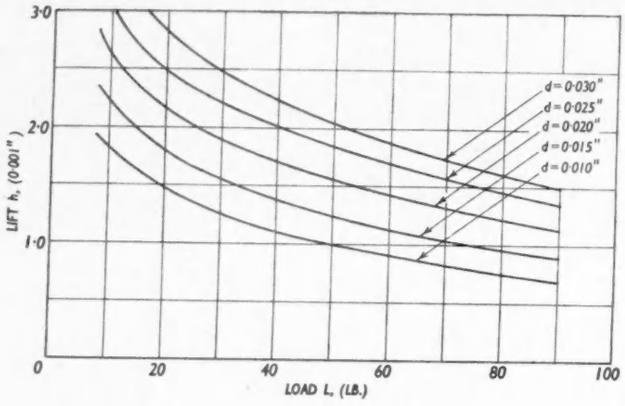


Fig. 3

Loads are applied to the centre of the bearing by means of a wire which passes through the base and carries a weight carrier at its bottom end, shown in Fig. 1 (*a*).

In order to measure the variations in lift of the air bearing, it is provided with four flat and coplanar pads at its four corners. Conventional air gauges, which have been previously adjusted and tested to give a suitable linear range and sensitivity, are supported over these pads. The required lift readings are then obtained on a mercury column, which can be read to an accuracy of 0·01in mercury equivalent to a movement of the bearing of 3×10^{-6}in. The free air flow to the bearing is measured on a "rotameter" placed in the air supply line, the flow reading being accurate to about 2 per cent of the full scale readings. Fig. 1 (*b*) illustrates the general arrangement of this equipment.

Test Procedure

In general, the test procedure consisted of taking lift and flow readings for each condition of load and supply pressure. For the purpose of the lift readings the zero position was taken as that where the bearing was in contact with the baseplate, the air supply being cut off. Readings on the mercury gauge were taken at the four corners for this zero position and subsequently for the various floating positions, the differences, after conversion from inches mercury to actual movement, being taken as the lift of the bearing. The plotted values are the means of the four corner readings taken with both increasing and decreasing lift. It was found that, for any set of readings (varying either load or supply pressure), the repetition of lift readings was of the order of 0·00003in. If the bearing was for some reason removed from the baseplate and replaced again between two readings, the repetition was about 0·00005in. If, in addition, the orifice plugs were removed and replaced between sets of readings, the repetition then became 0·00015in. In the latter case, variations of set-back, however slight, may cause some lack of repetition.

Using the above procedure, a large number of tests was carried out and these are described below. The above remarks on accuracy should be borne in mind when studying the curves in Figs. 2 to 9, e.g. the values for variation in lift h should not be assessed to closer than 0·00005in.

(1) *Effect of Variation of Orifice Diameter and Orifice Set-Back.*—In order to investigate the effect of changes in orifice diameter and set-back on the flow, lift and stiffness of the air bearings, a series of tests was carried out at 40 lb per square inch supply pressure for five different sizes of orifice, each $\frac{1}{8}$in long and having diameters of 0·010in, 0·015in, 0·020in, 0·025in and 0·030in, and four orifice set-backs of 0in, 0·003in, 0·005in and 0·009in, the orifice plug diameter in each case being $\frac{1}{8}$in. In each test the load was increased from 8 lb (the weight of the bearing itself) to a maximum of 90 lb in steps of 5 lb. For each step, readings of flow and lift were taken with both increasing and decreasing load. A typical set of graphs of lift against load for different set-backs is that shown in Fig. 2, which was taken on the $13\frac{1}{2}$ square inch bearing for an orifice diameter of 0·010in. In Fig. 3 the results are plotted in a different way. Here the graphs are plotted for a fixed orifice set-back of 0·009in and for the five orifice diameters, again on the $13\frac{1}{2}$ square inch bearing. Fig. 4 shows a typical curve of air flow against load for a fixed orifice diameter of 0·010in and various orifice set-backs on the $13\frac{1}{2}$ square inch bearing.

The graphs given in Figs. 2, 3 and 4 are typical of a large number of similar graphs obtained for the two bearings with the range of orifice diameters and set-backs mentioned above. The effect of the orifice set-back on the lift of the bearing is clearly shown in Fig. 5, where the results are plotted for the $13\frac{1}{2}$ square inch bearing under a fixed load of 40 lb and for the five different orifice diameters. All the above results were taken with an air supply pressure of 40 lb per square inch and their significance is discussed in a later section of the report.

(2) *Effect of Variations of Supply Pressure.*—In order to determine the effect of varying air supply pressure to the bearing, tests were carried out for pressures of 20 lb, 40 lb, 60 lb and 80 lb per square inch with an orifice diameter of 0·020in and set-backs of 0in and 0·003in on both bearings. A typical set of curves of lift against load is shown in Fig. 6 for the 6 square inch bearing with 0·020in orifice diameter and 0·003in orifice set-back. The corresponding curves of flow against load are shown in Fig. 7.

In addition, it was thought desirable to obtain a measure of the variations of lift for small changes in supply pressure. For this purpose further tests were carried out on the 6 square inch bearing with 0·020in orifice diameter and set-backs of 0in and 0·003in. In these tests the applied load was held constant at 20 lb and 50 lb respectively, and the supply pressure was varied in small steps from 80 lb per square inch until the air film supporting the bearing collapsed, readings of lift being taken at each step. A typical set of results is shown in Fig. 8 for the 6 square

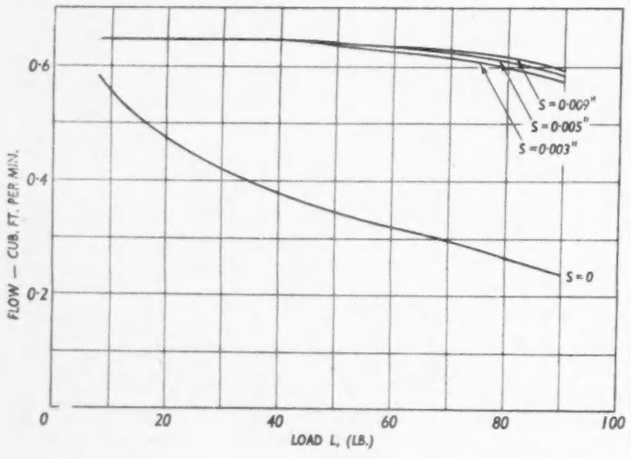


Fig. 4

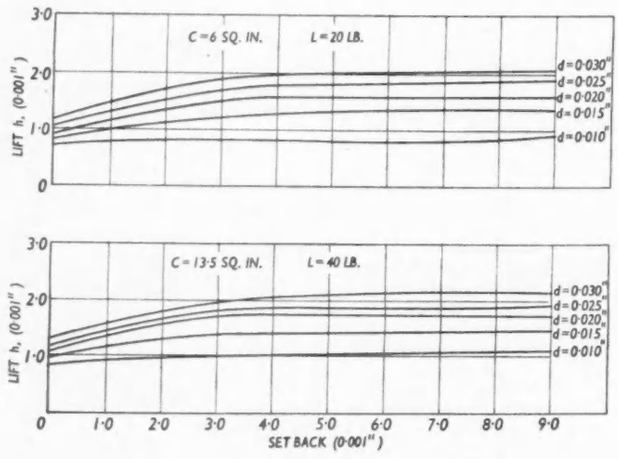


Fig. 5

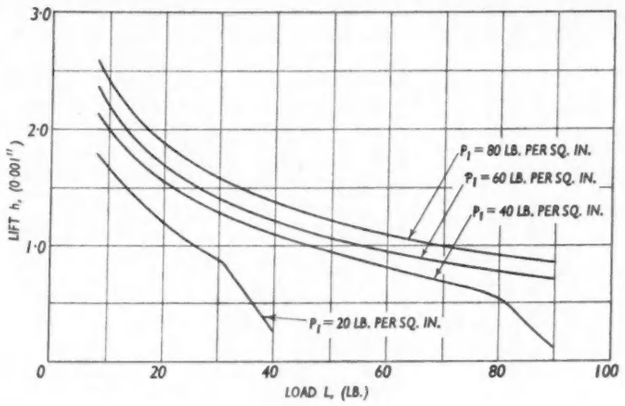


Fig. 6

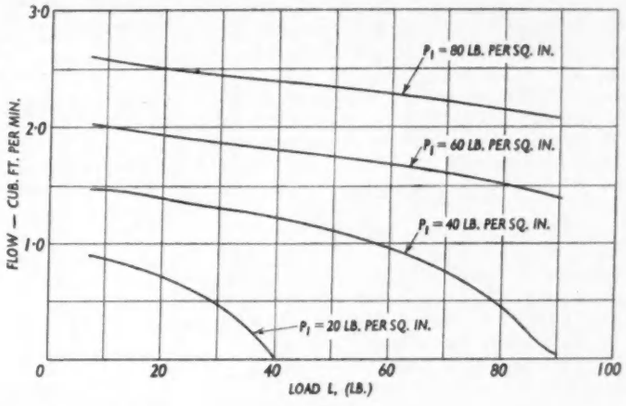


Fig. 7

inch bearing with 0·020in orifice diameter, 0·003in orifice set-back and loads of 20 lb and 50 lb.

These results are discussed in a later section. A comparison of the results in Fig. 8 with corresponding values obtained from Fig. 6 shows a reasonable agreement to within the specified accuracy of determination.

(3) *Effect of Variations in Orifice Plug Diameter.*—In order to investigate the effect of varying the diameter of orifice plug and hence the area of the orifice set-back, some of the tests carried out under section 1 were repeated with an orifice plug diameter of $\frac{1}{4}$in instead of $\frac{1}{8}$in. Tests were done for orifice diameters of 0·015in, 0·020in, 0·025in and 0·030in, and set-backs of 0in, 0·003in, 0·005in and 0·009in, all at 40 lb per square inch supply pressure. A typical set of curves of lift against load is shown in Fig. 9 for the $13\frac{1}{2}$ square inch bearing and orifice diameter of 0·015in.

Results

(1) From the graphs of lift against load such as the one shown in Fig. 2, it can be seen that, in general, the curves all follow a similar course until they approach the zero lift position, when they fall off at a steeper gradient to zero. The effect of orifice set-back is to increase the lift up to a certain value of set-back, beyond which no effect is noticeable. In all the tests carried out here, a set-back of 0·009in was found to be sufficient to obtain the maximum effect in the $13\frac{1}{2}$ square inch bearing, while 0·003in set-back was adequate for the 6 square inch bearing, as can be seen in Fig. 5. This effect is also noticeable from the point of view of load-bearing capacity in the 6 square inch bearing.

(2) The relation of load-bearing capacity to supply pressure and bearing area can be seen on the smaller bearing (it was not possible to load the larger bearing up to its full capacity), as shown in Fig. 6. The results obtained with zero set-back (not shown here) do not give the maximum load-bearing capacity, but those with a set-back of 0·003in shown in Fig. 6 can be assumed to do so. The values from the curves are approximately 40 lb for a 20 lb per square inch supply pressure and 90 lb for a 40 lb per square inch supply pressure. Therefore, if we assume that

load capacity $L_{max} = X \,.\, Pc$

where P = supply pressure (pounds per square inch)

c = bearing area (square inches),

then X is approximately $\frac{1}{3}$, which is the value found previously for various air bearings used in the laboratory. This figure will also be found to hold in some of the other tests where the bearing was loaded to its full capacity.

(3) Apart from load capacity, one of the other important design factors in a bearing is its stiffness, i.e. the load for unit deflection. This figure is in fact the reciprocal of the gradient of the load-lift curves at any point. It will be seen that the stiffness increases with load for any combination of orifice diameter, set-back, supply pressure, &c. (This does not take into account the part of the curve where the lift is decreasing very rapidly due to the proximity of the bearing to the base. In any case, the air gap in this region is too small for practical purposes). Table I shows values of bearing stiffness for various orifice diameters and supply pressures. From these it appears that there is a general tendency for the stiffness to decrease, as the orifice diameter is increased, though this result is subject to some scatter.

The effect of supply pressure is rather more obscure and, from the results above, there would appear to be no general trend of stiffness variation, as the supply pressure is varied. It should, however, be pointed out that, while the results dealing with orifice diameter are based on a large number of tests, those dealing with variation in supply pressure are taken from only a small group of tests and are, therefore, rather less conclusive.

(4) It is also of interest to note the effect of supply-pressure changes on the lift in a bearing under fixed load, as shown in Fig. 8, for two different loads. Apart from a rapid increase in lift at low-supply pressures, the relationship between lift and supply pressure is practically linear and the gradient is approximately the same for both loads. This tends to bear out the statement made above that variations in supply pressure do not have a marked effect on the stiffness of the bearing, other things being equal.

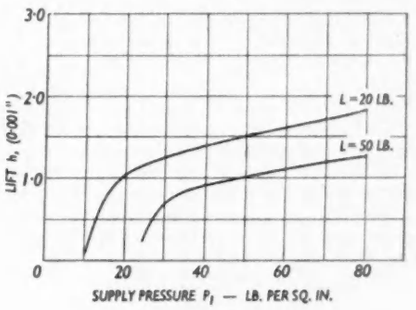


Fig. 8

(5) Another important factor from the point of view of economy in an air bearing is the required air flow. From the results obtained for both the 6 square inch and $13\frac{1}{2}$ square inch bearings, the flow ranged up to 4 cubic feet per minute, the actual value depending on load, orifice diameter and orifice set-back. In all cases the supply pressure was 40 lb per square inch. A typical curve of flow against load is shown in Fig. 4.

(6) Two sizes of bearings of $13\frac{1}{2}$ square inch and 6 square inch bearing area respectively were tested. For similar orifice diameters, set-backs and supply pressures, the larger bearing did float at a higher level, the

Table I—*Stiffness of Air Bearings* ($lb/in \times 10^4$)

Bearing area = $13\frac{1}{2}$ sq. in
Set-back = 0·009in
Supply pressure = 40 lb/sq. in

Load	Orifice diameter				
	0·010in	0·015in	0·020in	0·025in	0·030in
20	3·6	3·3	2·9	3·1	2·2
40	7·3	7·2	5·6	5·5	4·1
60	10·0	9·7	10·0	7·2	6·3
80	25·0	16·2	12·5	10·0	8·5

Bearing area = 6 sq. in
Set-back = 0·009in
Supply pressure = 40 lb/sq. in

Load	Orifice diameter				
	0·010in	0·015in	0·020in	0·025in	0·030in
20	4·5	3·3	3·0	2·7	2·2
40	8·3	8·2	5·5	4·6	4·1
60	12·5	8·2	6·4	5·5	5·5
80	10·0	4·5	5·0	4·1	4·1

Bearing area = $13\frac{1}{2}$ sq. in
Set-back = 0
Orifice diameter = 0·020in

Load	Pressure (lb/sq. in)			
	20	40	60	80
20	3·3	2·5	2·5	2·4
40	3·8	5·6	6·3	5·5
60	—	12·5	10·0	7·1
80	—	12·5	12·5	16·5

Bearing area = $13\frac{1}{2}$ sq. in
Set-back = 0·003in
Orifice diameter = 0·020in

Load	Pressure (lb/sq. in)			
	20	40	60	80
20	2·6	3·9	2·4	2·2
40	4·5	5·0	5·5	5·5
60	6·3	8·4	7·1	7·1
80	—	12·5	12·5	10·0

Bearing area = 6 sq. in
Set-back = 0
Orifice diameter = 0·020in

Load	Pressure (lb/sq. in)			
	20	40	60	80
20	—	2·9	3·6	3·1
40	—	7·1	8·3	6·3
60	—	—	10·0	12·5
80	—	—	—	16·6

Bearing area = 6 sq. in
Set-back = 0·003in
Orifice diameter = 0·020in

Load	Pressure (lb/sq. in)			
	20	40	60	80
20	2·8	2·9	2·5	2·7
40	—	6·3	6·3	5·5
60	—	7·1	7·1	7·1
80	—	—	12·5	20·0

Evaluation of Results

Let A = Orifice area.
h = Escapement gap.
c = Bearing area.
L = Load on bearing.
l = Half-width of bearing.
a = Length of bearing.
p_1 = Supply pressure (pounds per square inch absolute).
p_2 = Pressure at orifice exit.
p_3 = Atmospheric pressure or pressure at exit from gap.
G_1 = Mass flow through orifice.
G_2 = Mass flow through air gap.

lift, however, being less than proportional to the bearing area. It was impossible to test the full-load capacity of the larger bearing except for one test at 20 lb per square inch which, however, tends to confirm the relationship found for the 6 square inch bearing in section 2 :

$$\text{i.e. } L_{max} \simeq \tfrac{1}{3}P \cdot c.$$

It should, of course, be emphasised that the relationship only holds if the bearing is designed to its best efficiency, that is, with a sufficient set-back. This fact was proved by testing the same bearing working with equal supply pressure but without set-back.

As far as differences in stiffness of the two bearings are concerned, it seems possible that at the lower loads (say, 20 lb), the smaller bearing is somewhat stiffer, but as the load is increased this difference disappears and, in fact, at loads of 60 lb or more the smaller bearing becomes less stiff than the large one, due to the fact that it is approaching its load limit so that the air film is beginning to collapse.

(7) As mentioned previously, some tests were carried out on the larger bearing, using a $\frac{1}{4}$in orifice plug, so that the area of set-back was quadrupled. This seems to have no appreciable effect on lift or stiffness, as shown in Fig. 9, but as it was impossible to test this bearing to its full-load capacity, it is impossible to tell whether the increase in plug size had any effect on the load capacity.

(8) Summing-up these observations, it appears that the load-bearing capacity is not affected to an appreciable degree by orifice diameter, but that it is necessary to have an adequate orifice set-back to obtain a maximum load capacity. Apart from this, it is only affected by bearing area and supply pressure, to both of which it seems to be linearly related.

The bearing stiffness, on the other hand, is independent of orifice set-back or supply pressure for a given load, but does depend on orifice diameter being a maximum with a minimum orifice diameter. The effect of change in bearing area on stiffness seems to be slight and depends on load.

Evaluation of Results

It has been suggested[1] that the mass flow through an orifice is given by an equation of the form :

$$G_1 = Af_1(p_2 p_1)$$

or if p_1 = supply pressure = constant,

$$G_1 = Af_2(p_2).$$

Similarly, it has been demonstrated experimentally[2] that the mass flow through a small rectangular gap between two parallel plates is given by an equation :

$$G_2 = h^3 f_3(p_2 p_3)$$

or if p_3 = atmospheric pressure = constant,

$$G_2 = h^3 f_4(p_2).$$

For steady flow conditions, $G_1 = G_2$,

therefore, $Af_2(p_2) = h^3 f_4(p_2)$,

$$\text{or } h^3/A = f_5(p_2) \quad . \quad . \quad . \quad . \quad (1)$$

If we assume that the mean effective pressure under the bearing $= f_6(p_2)$,

then the load carried $L = cf_6(p_2)$,

$$\text{and hence } p_2 = f_7(L/c) \quad . \quad . \quad . \quad (2)$$

Hence, equating (1) and (2) :

$$h^3/A = f_8(L/c) \quad . \quad . \quad . \quad . \quad (3)$$

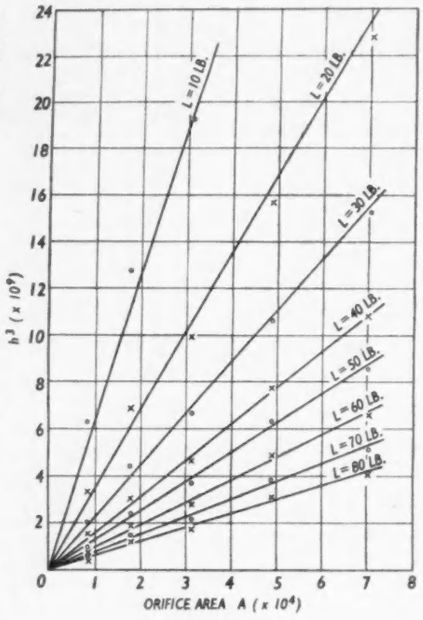


Fig. 10

In order to check this expression from the experimental results, h^3 was plotted against A for various values of load L and for both bearing areas c. A typical set of results obtained is shown in Fig. 10, which was plotted for the 13½ square inch bearing for a supply pressure of 40 lb per square inch, a set-back of 0·009in and values of load from 10 lb to 80 lb. Similar sets of results were obtained for set-backs of 0·009in, 0·003in and 0in on both bearings. In spite of scatter in some of the graphs, it was thought that for any given value of L/c, A and h^3 were in fact linearly related. By drawing the best straight line through each set of values it was, therefore, possible to obtain unique values of h^3/A for each value of L/c.

By plotting these values of h^3/A against L/c for any given set-back, it was found that the curves so obtained approximated to a rectangular hyperbola. It was, therefore, decided to plot h^3/A against c/L in order to obtain a straight line for all values of L and c. This was achieved for practical values of c/L (up to 0·4), as can be seen in Fig. 11. The three lines drawn here are for values of set-back of 0in, 0·003in and 0·009in and for a supply pressure of 40 lb per square inch.

The equations for these straight lines were calculated from the graphs and are :

For $S = 0{\cdot}009\text{in}$ $h^3/A = (5{\cdot}88c/L - 0{\cdot}38)10^{-5}$

$$\text{or } A = \frac{10^5 h^3}{5{\cdot}88c/L - 0{\cdot}38} \quad . \quad . \quad . \quad (4)$$

For $S = 0{\cdot}003\text{in}$ $h^3/A = (3{\cdot}5c/L - 0{\cdot}26)10^{-5}$

$$\text{or } A = \frac{10^5 h^3}{3{\cdot}5c/L - 0{\cdot}26} \quad . \quad . \quad . \quad (5)$$

For $S = 0$ $h^3/A = (1{\cdot}4c/L - 0{\cdot}16)10^{-5}$

$$\text{or } A = \frac{10^5 h^3}{1{\cdot}4c/L - 0{\cdot}16} \quad . \quad . \quad . \quad (6)$$

These results were then checked against experimental values by postulating value of h, c and L and comparing the resulting calculated orifice diameter with the actual one.

This is shown in Table II.

Table II

Bearing area C, square inch	Set-back S, inch	Lift h, inch	Load L, pounds	Calculated A, square inch	Calculated orifice diameter	Actual orifice diameter
13·5	0·009	$1{\cdot}46\times10^{-3}$	40	$1{\cdot}94\times10^{-4}$	0·0157	0·015
13·5	0·009	$0{\cdot}75\times10^{-3}$	80	$0{\cdot}99\times10^{-4}$	0·0112	0·010
13·5	0·003	$1{\cdot}69\times10^{-3}$	40	$5{\cdot}25\times10^{-4}$	0·0258	0·025
13·5	0	$0{\cdot}82\times10^{-3}$	50	$2{\cdot}54\times10^{-4}$	0·0180	0·020
13·5	0	$0{\cdot}45\times10^{-3}$	80	$1{\cdot}19\times10^{-4}$	0·0122	0·010
13·5	0·003	$1{\cdot}82\times10^{-3}$	40	$6{\cdot}55\times10^{-4}$	0·0290	0·030
6	0·009	$1{\cdot}22\times10^{-3}$	50	$5{\cdot}59\times10^{-4}$	0·0266	0·025
6	0·009	$0{\cdot}59\times10^{-3}$	80	$3{\cdot}31\times10^{-4}$	0·0205	0·020
6	0·003	$0{\cdot}81\times10^{-3}$	60	$5{\cdot}90\times10^{-4}$	0·0274	0·020
6	0	$0{\cdot}85\times10^{-3}$	20	$2{\cdot}36\times10^{-4}$	0·0170	0·015

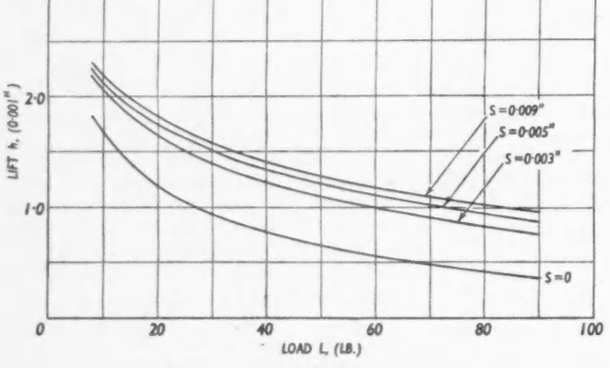


Fig. 9

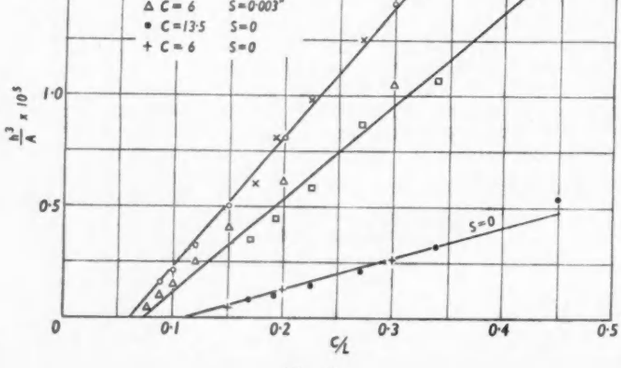


Fig. 11

From the table it can be seen that with one exception (where the experimental value does not seem to be in the correct relationship to the other experimental values) the agreement is satisfactory, bearing in mind that in general

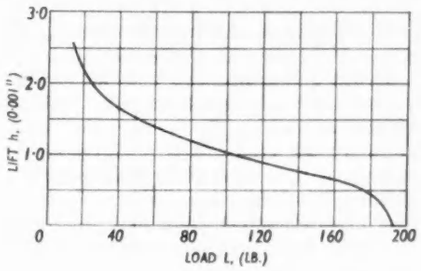


Fig. 12

the value of actual orifice diameter would only be known to an accuracy of approximately 5 per cent or even in the case of the smaller orifices, to approximately 10 per cent.

To find the stiffness of the bearing under various conditions, one proceeds as follows :

In general

$$h^3/A=10^{-5}(K_1c/L-K_2)$$

$$L=\frac{K_1c}{10^5h^3/A+K_2}.$$

Stiffness

$$=dL/dh=-K_1c(K_2+10^5h^3/A)^{-2}\,.\,3\times10^5h^2/A$$

$$=\frac{-3\times10^5K_1ch^2}{A(K_2+10^5h^3/A)^2}$$

$$=\frac{-3\times10^5K_1ch^2}{A(K_1c/L)^2}.$$

But

$$h^2=[10^{-5}A(K_1c/L-K_2)]^{2/3}$$

therefore

$$dL/dh=\frac{-3\times10^{5/3}L^2}{K_1cA^{\frac{1}{3}}}(K_1c/L-K_2)^{2/3}.$$

For $S=0{\cdot}009$in

$$dL/dh=-24\frac{L^2}{cA^{\frac{1}{3}}}(5{\cdot}88c/L-0{\cdot}38)^{2/3}.$$

For $S=0{\cdot}003$in

$$dL/dh=-40\frac{L^2}{cA^{\frac{1}{3}}}(3{\cdot}5c/L-0{\cdot}26)^{2/3}.$$

For $S=0$

$$dL/dh=-100\frac{L^2}{cA^{\frac{1}{3}}}(1{\cdot}4\,c/L-0{\cdot}16)^{2/3}.$$

This indicates that the stiffness is inversely proportional to the cube root of A and is related to c and L as shown.

In Fig. 12, load L is plotted against lift h for the 13½ square inch bearing, 40 lb per square inch supply pressure, 0·020in orifice diameter, and 0·009in set-back. The values for the curve are obtained from the empirical formula and agree closely with the practical values obtained. From this curve it appears that the stiffness is approximately constant from about 0·5 to 0·9 of the maximum load. Since the practical tests on the 13½ square inch bearing only reached 0·5 maximum load, this fact does not appear on the practical curves for this bearing but it is confirmed on the curves for the 6 square inch bearing, which was loaded to approximately maximum load, as shown in Fig. 6.

Conclusions

The empirical relationships for stiffness and lift given above are valid for the two sizes of bearing tested, provided that :

(*a*) $l/a=\frac{1}{2}$, i.e. for geometrically similar bearings.

(*b*) The bearings have the same distribution of orifices as the bearings tested, i.e. three orifices distributed so as to give $l/a=\frac{1}{2}$.

(*c*) Supply pressure equals 40 lb per square inch gauge.

(*d*) The mean effective pressure is greater than 2·5 lb per square inch (i.e. $c/L<0{\cdot}4$).

It will be appreciated that the above work applies to steady conditions of loading. The effect of dynamic loading is being investigated together with the application of the above results to cylindrical bearings.

Acknowledgements

The author wishes to acknowledge the assistance given by Mr. D. S. Winning, who carried out a large part of the experimental work.

The work described above was carried out in the Mechanisms, Metrology and Noise Control Division of the Mechanical Engineering Research Laboratory as part of the research programme of the Mechanical Engineering Research Board. It is published by permission of the Director of the Laboratory.

Appendix

Typical Design Example Using the Results Obtained.—It is required to design an air bearing to support a sliding table weighing 500 lb, a supply pressure of 40 lb per square inch being available. The bearing should be designed for maximum stiffness and minimum air consumption. For convenience of manufacture, orifice diameters of 0·020in are chosen.

The condition of minimum air consumption necessitates a zero value of set-back (from Fig. 4 and similar flow curves not published here). The condition of maximum stiffness requires the working load to be between 0·5 and 0·9 of the ultimate load (see Fig. 12). Using a figure of 0·6, this gives an ultimate load of 830 lb. Using equation (6) for an orifice set-back of zero, it can be seen that for the condition of ultimate load (i.e. $h=0$) :

$$c/L=\frac{0{\cdot}16}{1{\cdot}4}$$ for a supply pressure of 40 lb per square inch.

Therefore, the required bearing area

$$c=\frac{0{\cdot}16}{1{\cdot}4}\times830$$

$$=94{\cdot}9 \text{ square inches approximately.}$$

Using a bearing width of 1½in (as in the larger test bearing), this gives a total length of bearing of 63in approximately, which can be designed as two pads 31½in by 1½in each. In order to use the same orifice distribution as in the bearing tested, each pad should have twenty-one orifices, 1½in apart and ¾in from each end of the pad. Using this design, the value of lift h under the working load of 500 lb is given by :

$$h^3\,.\,10^5=A(1{\cdot}4c/L-0{\cdot}16),$$

where

$c=94{\cdot}5$ square inches.
$L=500$ lb.
$A=3{\cdot}14\times10^{-4}$ square inches (for a 0·020in orifice diameter),

whence $h\simeq0{\cdot}0007$in, which is a suitable bearing clearance for bearing pads manufactured to normal workshop tolerances.

The stiffness of the bearing to small changes of load is obtained from equation (9).

$$\frac{dL}{dh}=100\frac{L^2}{cA^{\frac{1}{3}}}(1{\cdot}4c/L-0{\cdot}16)^{2/3},$$

where

$L=500$
$c=94{\cdot}5$
$A=3{\cdot}14\times10^{-4}$

whence

$$\frac{dL}{dh}\simeq860{,}000 \text{ lb per inch.}$$

A bearing has been designed and manufactured to this specification. Tests carried out give the following results.

The bearing was loaded in steps of 50 lb up to a total load of 750 lb. The lift was measured for each load value and the relationship between lift and load between loads of 500 lb (the weight of the bearing itself) and 750 lb was found to be linear with a stiffness of 885,000 lb per inch, which agrees closely with the calculated value. The lift of the unloaded bearing (i.e. at 500 lb load) was found to be 0·00055in. The small difference between this and the calculated value of 0·0007in is probably due to lack of flatness in the bearing pads, giving a false zero lift value.

References

[1] E. Ower, *The Measurement of Airflow*, Chapter VI.
[2] G. L. Shires, "Viscid Flow of Air in a Narrow Slot," *N.G.T.E. Memorandum M46* (1949).

Light Rock Drill

A new version of the "CP9" percussive drill which is designed as a miniature rock drill, weighing only 7½ lb, is now being produced by the Consolidated Pneumatic Tool Company, of 232, Dawes Road, London, S.W.6. This tool is a fully self-rotating percussive hand drill with a wide range of application. It is fitted with a rotating chuck, a quick-change steel retainer for

Small rock drill weighing 7½ lb and fitted with rotating chuck

rotating drill steels, or non-rotating chisels, a new design valve, a built-in oiler, and a right or left-hand exhaust. The cylinder bushing is renewable and a graduated throttle valve has a leak proof, renewable rubber seat.

Hollow rotating drill steels supplied for the drill enable a jet of air to be directed to the drill point, keeping it cool and removing dust and chippings to prevent "packing." Rotating hexagon-shanked drill steels and round-shanked non-rotating chisels are retained by four balls in the rotating chuck. Steels are quickly released by pulling back the spring-loaded chuck sleeve. The overall length of the tool, which can be seen in our illustration, is 14½in.

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

FRENCH LOCOMOTIVE EXPERIENCES

SIR,—For the second time, I am glad to write and thank you for the issues of THE ENGINEER you have so kindly sent me. I had the opportunity to write to you in September, 1954, in token of my gratitude for the first series of articles in THE ENGINEER containing "French Locomotive Experiences," by Edward Livesay. I am still keeping those fine issues, not only for the railway articles (because, belonging to railways, I care very much for them), but for the many very interesting technical studies they contain.

I decided to write again to you with my comments upon Mr. Livesay's latest articles, and to let you know that other officials of the S.N.C.F. agree with my appraisal. It is all the same with the new series of experiences related by Mr. Livesay, concerning his visit to the French Railways in 1956. This time, again, I was with Mr. Livesay, to attend him on the engines of our Northern Region, and this is why, once more, I take the liberty to write to you, in order to give you my opinion, in spite of my wording !

These latest articles are as interesting and exact as the former ones. One can see at once they were written by a most competent and keen observer. The only criticism I could make of them is that they are much too short for my fancy ! Please understand—I mean to say that Mr. Livesay did not remain long enough with us !

Once again, I say that there is no mistake important enough to make it worth while correcting. I was only a little surprised when I read the No. 2 about the high-speed test runs, where Mr. Livesay says "the engine was riding rough!" Certainly it was, but not too badly, considering the high speed attained and the abnormal conditions in which "E19" had to perform its work (with a dead electric locomotive in front), as Mr. Livesay himself explains.

I think he was a bit severe, but he may be condoned as he had not yet taken lunch ! And I can affirm that the "tail-wagging" gave him a ravenous appetite !

Now, I thank you once more, and I should be very glad if you would let Mr. Livesay know how much his articles are appreciated in France.

The first time he came to France, so apprehensive, as he said, and we travelled together with Monsieur Leseigneur (the Kings' driver and the king of the drivers !) on the footplate of the engine of the "Golden Arrow," I said to him, after a happy hour at "La Maison Blanche," near the Gare du Nord, that at Calais, he was a stranger to us, but, at Paris, he was already our friend. And this is now more true than ever !

I beg you to excuse again my having treated your language so badly and I hope you will understand me in spite of this. I have said this also to Mr. Livesay, but he I think he pretends—for he is very polite—in a little while we will make of him a good Frenchman !

B. F. FILLON

St. Ouen,
France.

RAILWAYS INTO ROADWAYS

SIR,—After following the debate on this subject with its increasingly complicated statistics, and while not disputing that railways need much reform and shedding of obsolete impedimenta, one is tempted to ask if the whole argument is not somewhat pointless.

It seems logical to expect that after having taken up the tracks, &c., and replaced them by roads at enormous trouble and cost, and then filled them with the same or a greater number of vehicles than the present number of coaches and trucks, a system of traffic control and timetable working would immediately become necessary, instead of the existing haphazard working of most road traffic.

A further logical development would be the greatest possible increase in vehicle size, and their coupling together, to obtain the highest ratio of load to operating manpower approaching the high ratios now obtained. Ultimately, coupling of more than three or four would encourage the redevelopment of some form of guiding track until the final result would be—to all intents and purposes—a railway as before except modernised—which is surely the current intention at a less cost and without the drastic upheaval of what is in essence a well tried system throughout the world !

C. G. DAHL, A.M.I.Mech.E.

Guildford, Surrey,
August 26, 1958.

SIR,—Some weeks ago the Railway Conversion League sent me a copy of Brigadier Lloyd's "Twilight of the Railways," and later the Brigadier referred me to the correspondence in THE ENGINEER, which I have read with interest. But I am still without information on several points, e.g. "What would be the real cost of transport on the new motor roads ?" and "What charges are to be made for the use of them by coaches, lorries, and private cars ?"

No one, I think, has denied that rubber-tyred vehicles, running on macadamised roads, require more fuel and manpower than steel-tyred trucks and coaches running on steel rails. Therefore, if the owners of motor lorries and coaches can offer lower charges than British Railways for the same services, it must be because they are allowed to throw part of their working expenses on someone else. Most people, when using the railway, think of the train as the thing they pay for ; in fact the train is only the last of many services which the railway-owner has to perform. A railway company had to buy the land for its lines and stations, build its tracks and depots (paying local rates on them), maintain, signal, police, and light them. All this is done for the motor-owner by the ratepayers, who have always been, in a sense, the biggest railway shareholders.

In fact the motor-owner finds his "permanent way"—the road—provided by the ratepayers, so that the traveller by motor coach or the trader who sends goods by a lorry, is right in thinking that the coach, or lorry, is the thing he pays for. Note here that our railways have been handicapped from the beginning by the absurd Parliamentary rule that they must calculate their passenger fares on a mileage basis, without adding a penny for "terminal" expenses. Most of the short-distance passenger traffic has always been carried at a loss, which is made up partly by huge profits on long-distance expresses. My own suggestion is that a penny or twopence should be charged for the ticket, with threepence a mile for the first 3 miles ; then twopence for the next 97 miles, with three-halfpence for anything over 100 miles.

Everyone can remember the effect of "smog" on the London death rate. Is it wise to increase this danger by substituting poisonous oil exhaust for coal smoke ? Is it safe to trust all our transport to imported oil ? My own suggestions are simple : (1) discourage long-distance goods traffic on the roads by special duties on long-distance licences, and (2) heavier duties on the heavier lorries. Also higher duties on the higher-powered cars and coaches. Why not experiment with disused branch lines turned into motor roads ?

J. E. ALLEN

Cambridge,
August 23, 1958.

SIR,—The statistics relating to London Bridge station given by Mr. G. T. Moody, in your issue of August 29, indicate that the to-and-fro flow into, out of and through that station amounts to about 160,000 passengers a day. In England that may seem a lot, but in the city of Seattle, U.S.A., there is to be a freeway of designed capacity 160,000 vehicles a day (17,000 an hour). Its noteworthy feature, in the context of Mr. Moody's letter, is that it will be comparable in width with the railway beyond London Bridge station. It therefore conveniently exposes that railway as a route the capacity of which has been choked right down—by rails. At present, reserved for railway trains, it can deal hourly with perhaps 68,000 passengers, most of them being crammed into the railway coaches because of the impossibility of cramming into the railway timetable the additional trains that are needed on this route : were it paved, and then reserved for 40-seater motor coaches, it could pass 680,000 passengers per hour, properly seated. In case someone with an eye for the elementary writes to say that that number of people would never need to use the route—which is a radial route serving only the 55 deg. south-easterly arc of the metropolitan circle—I would draw attention to the real significance of the figure 680,000 : which is that it shows how lightly trafficked London's plentiful radial routes would be if converted from

railways into freeways. Even during the rush hours there would be ample room on them for other vehicles besides the motor coaches. Those other vehicles could be the cars of commuters preferring to drive themselves. Where could they park ? The obvious answer is on the site of London Bridge station, demolished : few rail commuters would cherish happy memories of it ; and, being twenty-two platforms wide, it would make a splendid site for a multi-storey car park in addition to serving as a motor coach station. Cannon Street could become the terminal motor coach station, with perhaps a shopping centre overhead—which is only typical of the urban planning possibilities consequent on railway conversion.

T. I. LLOYD

Railway Conversion League,
123/124, Newgate Street,
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September 6, 1958.

Book Reviews

Dock and Harbour Engineering. Vol. I. The Design of Docks. By H. F. CORNICK. Charles Griffin and Co., Ltd,. 42, Drury Lane, London, W.C.2. Price 105s.

THE book under review is the first volume entitled " The Design of Docks " of a series of four volumes which between them give a comprehensive view of the general subject " Dock and Harbour Engineering." The present work follows upon earlier works by Dr. Brysson Cunningham which have up till now been regarded as the standard books on this subject.

When first confronted by the immense mass of information and erudition contained in Volume I every dock and harbour engineer is bound to gain a fuller appreciation of the scope and complexity of the branch of engineering in which he has himself been engaged. The first four of the six chapters in Volume I are mainly descriptive in character. They contain information illustrated by many excellent reproductions of engineering drawings gathered from all parts of the world describing the problems in dock design with which engineers have been faced in the past and the solutions which have been adopted, together with the reasons which led to the adoption of them. The last two chapters deal more particularly with graving and floating docks, with slipways and with dock gates. Judging, however, from the subtitles of chapters yet to be published there is still a great deal more, particularly on the design side, which the author intends to add in the later volumes.

A monumental work of this description suffers from two disabilities which are perhaps unavoidable. As a historical record of what was actually done at a certain place at a certain period of time the information, drawings and so forth recorded in a work of this nature are necessarily somewhat curtailed and the information regarding the reasons for what was done is necessarily somewhat incomplete, so that anyone seeking to reach a full understanding of any particular project referred to in the text will have to refer to other records, such as the actual papers read before and published by the Institution of Civil Engineers or other bodies. It is a disability in a book of this kind that the recorded plans and information do not convey the whole story. The other disability is that the recorded matter is usually out of date. A large proportion of the works illustrated and described in the book were designed and constructed a long time ago when the constructional materials available were quite different from what they are now, when the constructional plant and methods of carrying out work were quite different and when there was an almost unlimited supply of cheap labour available.

There has in fact lately been a revolution in construction work, both in the matter of design, in the nature of the materials made use of, and in the methods of construction, and this fact has the effect of rendering the subject matter of such a book as this somewhat obsolete. Not everything is obsolete, but some things are and the danger to a student of engineering reading such a book is that he may confuse the two. If, for example, it were desired to criticise the last chapter of Volume I dealing with dock gates, it would have to be noted that there is no mention of floating reinforced concrete gates which, where they can be employed, are the cheapest and simplest form of dock gate ; nor is there more than a bare mention of the flap-up type of steel dock gate, which to-day has largely superseded the older kinds that are so carefully described in the text.

The two disabilities above mentioned do not detract from the value of the present work regarded as a record of the progress of dock and harbour engineering up to ten years ago. Considered moreover as a book of reference whereby any practising engineer or student can without too much effort make himself acquainted with the state of prior art, Mr. Cornick's work on dock and harbour engineering will be invaluable.

Vibration and Impact. By R. BURTON. Academic Books, Ltd., 129, Queensway, London, W.2. Price 68s.

MANY of the well-known textbooks on the theory of vibration have reappeared recently as revised and enlarged editions. It is therefore refreshing to see an entirely new work. The author would appear to be devoted to his subject. He goes so far as to say, in the preface, that an understanding of the basic principles of vibration and oscillatory phenomena in general is needed by all engineering students, regardless of what their special interests may be ; and that " important educational values " are inherent in the study of vibrations. This admirable viewpoint has not, however, led to a single generalised theory covering all aspects of vibration, any practical system being merely a simplified case of such a theory. The reverse is very much in evidence. The reader is advised to work nobly through the entire book, thereby being taken very gently from the simplest problem to the more complex. The result is a typical textbook suitable for most university undergraduate courses, but not very stimulating for the expert.

An interesting innovation is the introductory chapter, which deals almost exclusively with the history of the subject, including a brief description of some of the early experiments. The one-degree-of-freedom system is considered in the next four chapters, first, for free vibrations, then with damping, followed by the complete case with a harmonic disturbing force. The governing equations of motion are derived carefully, no attempt having been made to generalise. The Lagrangian equations are not included, quite rightly, for a book of this scope. Damping includes systems with dry friction or hysteresis loss. Negative damping leading to instability is also briefly referred to with particular reference to aerodynamic damping and flutter. Impact is considered in Chapter 6 and the usual theory is discussed with only very few examples. This hardly warrants the inclusion of the word impact in the title. Arising from impact, the theory of wave propagation in elastic bodies is, however, dealt with fairly fully in Chapter 11. The remaining chapters are devoted to systems with many degrees-of-freedom, vibrating beams, non-linear vibrations, measuring instruments and analogues, control systems and fatigue. The treatment of each of these topics is a good thorough introduction, although somewhat lengthy in parts. To find a simplified diagram of a cathode-ray tube in the chapter on measuring instruments would seem unnecessary ; it would have been more appropriate and useful to derive the theory of seismic instruments and to show under which conditions the reading is proportional to displacement, velocity or acceleration. The short chapter on fatigue of metals would also seem unnecessary except to remind the reader of the very serious consequences that can occur if his machine should develop excessive vibrations.

The book is very well produced with many excellent diagrams and worked and unworked examples (answers given). A good feature is the list of suggested further reading at the conclusion of each chapter. There is a subject and a name index.

An Analysis of the Error Involved in Unrolling the Flow Field in Turbine Problems. By VERNON J. ROSSOW. Mitteilungen aus dem Institut für Aerodynamik der ETH, No. 23. Verlag Leemann, Arbenzstrasse 20, Postfach, Zürich 34. Price S.Fr.16.

WHEN the number of blades of a turbine becomes very large (hub/casing diameter ratio ν nearly 1), the flow field may be assumed to be approximately two-dimensional. The potential to be added, in the three-dimensional case, was given for the flow field near the vortex by Ginsburg (1956). Equations describing the three-dimensional flow in the region not near the vortex are studied in this paper, and a similar expression is found for the source line between hub and casing. Results are compared with previous electrolytic tank measurements, for ν varying between 0·3 and 1.

Books Received

Water Power Engineering. By Rolt Hammond. Heywood and Co., Ltd., Ingersoll House, 9, Kingsway, London, W.C.2. Price 50s.

Great Western Steam. By W. A. Tuplin. George Allen and Unwin, Ltd., Ruskin House, 40, Museum Street, London, W.C.1. Price 25s.

Pumps, Fans and Compressors. By A. De Kovats and G. Desmur. Blackie and Son, Ltd., 17, Stanhope Street, Glasgow, C.4. Price 45s.

Problems in Workshop Calculations. By W. A. J. Chapman. Edward Arnold (Publishers), Ltd., 41, Maddox Street, London, W.1. Price 6s.

Underground Lighting in Mines, Shafts and Tunnels. By A. Roberts. The Technical Press, Ltd., 1, Justice Walk, Chelsea, London, S.W.3. Price 63s.

Inorganic Fibres. By C. Z. Carroll-Porczynski. The National Trade Press, Ltd., Ingersoll House, 9, Kingsway, London, W.C.2. Price 57s. 6d.

Progress in Semiconductors, Vol. 3. Edited by A. F. Gibson. Heywood and Co., Ltd., Ingersoll House, 9, Kingsway, London, W.C.2. Price 55s.

The ABC of Atomic Energy. By Sir Christopher Hinton. The British Broadcasting Corporation, 35, Marylebone High Street, London, W.1. Price 1s. 3d.

Motor Vehicle Exercises in Calculation. By H. G. Miles and L. W. F. Elen. Cleaver-Hume Press, Ltd., 31, Wright's Lane, Kensington, London, W.8. Price 5s. 6d.

Functions of Real and Complex Variables. By W. F. Osgood. Chelsea Publishing Company, 552, W. 181 Street, New York, 33, N.Y., U.S.A. Price : 4.95 dollars.

Theoretical and Experimental Analysis of Members Loaded Eccentrically and Inelastically. By Omar M. Sidebottom and Marlyn E. Clark, University of Illinois, 2, Administration Building (East), Urbana, Illinois, U.S.A. Price 1 dollar.

Heat and the Engineer

By PROFESSOR O. A. SAUNDERS, F.R.S.

In his Presidential Address to Section G of the British Association delivered on August 29 and here in part printed, Professor Saunders gave particular attention to problems of heat transfer. Amongst other matters he spoke about the fundamental theory and dimensional analysis; and he discussed regenerators, aerodynamic heating, dropwise condensation, effusion cooling, the radiation from furnace flames and the use of liquid metals.

The Fundamentals of Heat Transfer

THE science of heat transfer remains based on the three elementary processes of radiation, conduction and convection, but to these have been added heat transfer with change of phase, as in evaporation and condensation, and with chemical reaction. The greatest difficulties of the subject arise from the complicated conditions in which these processes operate in practice. The basic differential equations of conduction and convection have been known for over a hundred years, but the boundary conditions for which solutions existed were for a long time so restrictive as to be of very limited use to the engineer. During the last quarter of a century the situation has changed greatly with the advent of numerical methods, including relaxation techniques and of digital and analogue computers. In the field of conduction to-day, for example, even for unsteady state problems, there is no reason why any problem, however complicated the boundary conditions, cannot be solved given the necessary time and equipment. As an example, the temperature distribution in an axisymmetrical steam turbine rotor during the initial starting up period has recently been found in my department by using an electrical resistance analogue computer, this investigation being a necessary prelude to studying the thermal stresses involved, which are crucial matters to the designer. The shape of the rotor is very complicated, and, indeed, it is from the shape that the problem of stress concentration arises.

In convection, which is perhaps the most difficult branch of heat transfer, great progress has been made in solving the boundary layer equations for laminar flow for both free and forced convection and, as in the case of conduction, we are now in the position that with the aid of computers we can solve almost any problem. For example, solutions have been given for forced convection laminar boundary layer flow with temperature-varying physical properties, with and without fluid injection or removal at the surface. Recently cases of non-uniform surface temperature have been treated, starting by the stepped temperature distribution, which leads to the case of any arbitrary temperature distribution at the boundary. In free convection also, many new cases such as uniform heat input to a vertical plate have recently been solved. In fact, to sum up, there is not much research interest left in solving laminar flow convection problems since it is now largely a question of feeding the particular conditions into a computer.

We are left, however, with turbulence, and here the position is quite different, as indeed is the case in any branch of fluid mechanics. Unfortunately the pace of modern industry is such that the flow is turbulent in the majority of applications. We still have to rely on experiment for finding turbulent heat transfer, even though considerable progress has been made towards understanding the temperature distributions in fluids in turbulent motion. The fundamentals of the relation between heat transfer and friction for turbulent flow were given in the middle of the last century by Osborne Reynolds, and we still use developments of his method to-day. An example of this is the gas-cooled nuclear reactor in which the need for minimum pressure loss in the carbon dioxide flow is very important since some 4 per cent of the final power output has to be fed back to drive the circulating fans, reducing the overall efficiency from 25 per cent to 21 per cent. The particular geometrical conditions of this application are a little unusual in that the gas flows through a long annular passage with heat flowing into it from a finned surface on the inner side, the heat flow being distributed in a non-uniform manner controlled by the neutron flux distribution, a set of conditions obviously not to be found in the textbooks. The flow is turbulent and the problem is to design the fins on the inner core so as to give satisfactory heat transfer coefficients everywhere with a minimum of pressure loss. This problem is actually a new and complicated variation of a very old engineering heat transfer problem, namely to get heat transfer without excessive pressure loss by varying the geometry of the boundary such as by roughening, grooving or other devices, a topic on which large numbers of patents have been taken out for boilers, heat exchangers, &c. It has always seemed to me that, in very oversimplified terms, success depends on creating turbulent eddies in the places where the temperature gradients are a maximum and so far as possible to produce larger and slower-moving eddies rather than smaller faster ones, although, of course, there are limits to the extent to which this can be done. The developments in design of fins for the uranium cans in the new power stations will be followed with much interest.

Dimensional Analysis

Some thirty years ago the engineer received much help in correlating experimental heat transfer data, particularly for turbulent convection, by the use of dimensionless groups of variables, and the use of Reynolds, Prandtl, Grashof and Nusselt numbers and Mach numbers is now universal, with more recent additions such as the Schmidt number for evaporation, Knudsen numbers for rarefied gases, and so on. It is rather remarkable that only during the last few months a new extension of dimensional analysis has come to light, namely vectional dimensional analysis which is based on the consideration of vectorial lengths in, say, the three directions of Cartesian co-ordinates, as independent fundamental units, instead of using only one unit of length as in ordinary dimensional analysis. This immediately leads, for laminar flow, to the relation $Nu/\sqrt{(Re)}=f(Pr)$ for forced convection and to $Nu/\sqrt{(Gr)}=F(Pr)$ for free convection, with an interesting extension to cases of combined forced and free convection by including an additional independent variable group Re^2/Gr on the right-hand side.

It may be objected by the mathematically minded that these results follow immediately if we write the basic boundary layer differential equations in non-dimensional form, which is indeed true, but the approach through dimensional analysis is of fundamental and educational interest, and may be of value in studying new problems. It is also of interest that vectorial dimensional analysis applies only to laminar flow and not to turbulent flow; in fact, it distinguishes the two on purely dimensional arguments. The reason, of course, is that in turbulent flow the directions of local viscous shearing and local conduction are not exclusively parallel to the surface, as they are for laminar boundary layer flow, with the result that prescribed vector dimensions cannot then be attached to the viscosity and thermal conductivity.

Turning to radiation, apart from determination of surface emissivities for different wavelengths, the main unknown fields are semi-transparent media, and radiation from clouds of particles in the important practical case of the luminous flame. The real difficulty in all these problems lies in determining the local radiation and absorbing the properties, which in the case of flames are linked with the rate of carbon formation in the combustion process. These and other fundamental problems will be referred to again later with reference to some practical applications.

In the general field of heat transfer with change of phase, progress has been made recently with the solution of boundary layer problems with simultaneous heat and mass transfer and we are now able to treat theoretically such matters as combined evaporation and heat transfer from wet or subliming surfaces.

The Regenerator

The regenerator is one of the oldest forms of heat exchanger, large brickwork regenerators beneath steel-melting and other types of furnaces being very common from the earliest days of furnaces, for the purposes of preheating air or gas to obtain higher flame temperatures and to recover waste heat. These regenerators also had the advantage that by the use of ceramics rather than metal, as in recuperators, high working temperatures were possible before the discovery of heat-resisting metal alloys.

The regenerator is, however, apart from the use of ceramics, fundamentally a very attractive principle of heat exchange because it uses the same passage for alternate flow of hot gas and cold air, instead of two passages separated by a dividing wall as in the recuperator. This eliminates the mechanical problem of separately sealing off each individual tube as in the tubular recuperator, and allows a better shape of flow passage for both fluids instead of, for example, the tortuous flow across baffled tube banks of a tubular recuperator. Also there is the possibility with regenerators of making the individual flow passages so small that the flow is laminar, and thereby reducing the ratio of friction pressure loss to heat transfer, which would be impossible with tubular recuperators in which tubes smaller than ¼in have not been contemplated for any large-scale exchangers because of the enormous problem of sealing tens of thousands of tubes into endplates. The thermal recovery of a regenerator can also be raised to very high values, over 90 per cent, by so arranging the temperature distribution within the solid

that it resembles that in a counterflow recuperator, and by choosing the periodic time between reversals small enough for the solid temperature to fluctuate only slightly. These ideas on regenerators, which represent a new departure from the old massive brickwork regenerators of the steel works, were first pointed out by Ritz after the war, but despite the advantages just described the use of regenerators in industry has not yet extended much because of practical difficulties in finding a satisfactory mechanical arrangement. Two methods are possible, either to use stationary solid matrices with reversing valves, or to use a form of continuously rotating matrix, such as a disc or cylinder, part of which is situated in the hot stream and part in the cold, so that the rotating matrix passes from one to the other. The former arrangement is clumsy, and the latter involves some form of rubbing or rolling seal. For applications where compactness is essential, such as the vehicle gas turbine, the rotating regenerator is very attractive, but the problem of developing a seal which is effective with pressure differences of two or more atmospheres and does not wear unduly, has not yet been solved. The whole future of the gas turbine for motor vehicles, and possibly other mobile applications, would be transformed by the development of a satisfactory regenerative heat exchanger, and although there are rumours of some success in U.S.A. by General Motors nothing has yet emerged.

High-Speed Heat Transfer and Missile Heating

The principles of aerodynamic heating are now fairly well understood. The dissipation of energy by viscous action in the rapidly shearing boundary layer air develops heat which is removed into the main airstream by conduction or eddy diffusion, but the two processes are so related that an equilibrium temperature is reached which, if the surface is unheated, is termed the adiabatic wall temperature and exceeds the main stream temperature by an amount depending on the Mach and Prandtl numbers of the stream. This excess temperature rises with the square of the Mach number, and at $M=5$ reaches about 1100 deg. Cent. for air at sea level temperature. Aircraft flying at supersonic speeds, and still more, missiles, therefore reach high temperatures even in the upper colder layers of the atmosphere, and metal models of conical missile heads have melted in a wind tunnel at $M=6{\cdot}9$ after only about twenty seconds. Even if the surface does not melt, except when the duration of high-speed flight is short, the penetration of heat into the structure is unacceptable, and even for short durations severe thermal stresses may be caused. Various ingenious means have been proposed to overcome these difficulties. For continuous operation a source of cold is needed and in an aircraft this means either a refrigeration plant or using the cold capacity of the fuel, which is substantial especially for supersonic transport aircraft which require large jet engines. The attractions of using a cold fuel such as liquid hydrogen are considerable since most of the sensible "cold" is in the form of specific heat rather than latent heat. The distribution of the "cold" throughout the aircraft structure and cabin is, however, no small problem. Another method, particularly for missiles, is to allow the metal surface, or some material coating it, to sublime into the air, thus abstracting latent heat at the surface. For all these purposes the designer needs to know heat transfer coefficients at very high Mach numbers, and although there is good evidence that the heat transfer is proportional to the difference between the surface wall temperature and the equilibrium adiabatic wall temperature up to Mach numbers of 4 or 5, there is still uncertainty concerning the heat transfer coefficients at very high Mach numbers. One difficulty is that there is evidence that the condition of flow in the boundary layer may be affected by the Mach number and also by the abstraction of heat, though this probably means a lower heat transfer coefficient than would otherwise be expected.

While on the subject of aircraft, the aeroplane is a good example of heat always being in the wrong place and requiring the heat transfer engineer to get it to the right places. First, there is abundant heat in the engine, and the engine designer is at pains to keep it away from vital stressed parts such as the turbine blades and bearings, and the waste heat in the exhaust is enormous. But the cabin requires heating and the wings and air intakes de-icing, and the designer even goes so far as to use electrical energy, converted from fuel heat at poor efficiency, for these purposes. Again, the oil and fuel must be heated to prevent undue frosting or freezing. Aerodynamic heating is a further nuisance at high speeds.

In connection with aircraft and aero-engines I encountered an interesting heat transfer problem in the early days of the last war, when I was asked by Sir Henry Tizard to consider means of injecting oxygen into Merlin aero-engines to restore the loss of power above the rated altitude, above which the supercharger is unable to maintain the maximum supercharge pressure, the aim being to raise the maximum ceiling to which fighter aircraft could climb, then about 36,000ft. It was immediately evident that the oxygen had to be carried as liquid, and a system was devised for injecting liquid oxygen into the air intake of the engine. A serious difficulty, however, was that on turning on the liquid oxygen from the supply tank, the 14ft pipe leading to the injection nozzle became vapour locked and a minute or so elapsed before the steady supply could be established, which was useless from the pilot's point of view. Insulation of the pipe was no help. In the end a double wall self-refrigerating pipe was devised with a number of small holes in the wall of the inner tube through which the liquid oxygen escaped into the annular space between the two tubes and cooled it mainly by evaporation. By suitably arranging the disposition of the small holes, the inner tube could be made to cool itself down to the boiling point rapidly enough for the liquid oxygen flow in the inner tube to become regular and full in a few seconds after turning on. Eventually, the appliance was installed in a fighter aircraft and raised its ceiling from 36,000ft to 38,000ft, also improving the mean rate of climb between 30,000ft to 35,000ft from 650ft a minute to 900ft a minute with a total duration of about fifteen minutes. But for the arrival of the gas turbine aircraft engines the device might well have had a much wider use.

Dropwise Condensation

For a long time it has been known that the heat transfer between a vapour and a surface upon which it is condensing, is much greater when the surface is not fully wetted and the vapour condenses as drops rather than as a continuous film. This conclusion was based on a simple measurement of steam condensing on a small surface, and coefficients of tens of thousands in British Units have been observed, compared with values of the order 1000 for film condensation. Incidentally, the precise physical mechanism of dropwise condensation is still uncertain, and we do not really know why it gives such high values. Although the absence of the liquid film through which the heat of condensation must pass to the surface obviously reduces the resistance to heat transfer, the proportion of the surface in contact with the drops is not large, and the drops themselves are not so small as to offer no resistance to heat conduction. It is disputed whether or not condensation can take place on the bare surface between the drops, and theories have been suggested which involve rapid turbulence in the vapour close to the drop surface caused by movement of the drop surface due to surface tension variation with temperature. Whatever the explanation may be there is no doubt of the fact, and the question of practical application has caused much interest, especially recently. The difficulty of promoting and maintaining the dropwise condensation has been substantially overcome in the case of steam condensers by the development at the Mechanical Engineering Research Laboratory of chemical additives of the mercaptan type, very small quantities of which are found to have the desired effect for quite long periods. The practical gain is, however, as so often happens in engineering, much reduced when we come to an actual plant. This is partly because most of the heat transfer resistance is on the cooling water side, and raising cooling water velocities, with familiar corrosion troubles, is necessary to take full advantage of dropwise condensation. Other important matters are the effect of small quantities of non-condensable air which appears to be more detrimental for dropwise than for filmwise condensation, and the fact that in parts of a condenser where the steam velocity is several feet a second the steam flow breaks up the water film and produces something resembling drops even under normal condenser operating conditions. Nevertheless, it is probable that power station condensers could be something like halved in size, and perhaps in cost, if a satisfactory dropwise condensing condition could be relied upon.

For vapours other than steam, in chemical engineering processes, the attractions of dropwise condensation are considerable, but unfortunately chemists have not so far been able to find a promoting substance which will adhere to stainless steel in the same way as mercaptans adhere to a copper-based alloy.

Effusion Cooling

The cooling of a surface by forcing gas or liquid coolant through pores or slits or holes was first mentioned by Duwez. The main cooling effect arises from the insulating layer of cool fluid interposed between hot stream and the surface, though heat is also removed from the wall by the coolant direct. The effect is increased if the fluid is liquid and vaporises on emerging from the wall surface. The theory of this process has been worked out for continuous injection, but in practice only the use of porous walls gives a continuous film, the effects of injection from slots or holes being localised. Porous injection also tends to be wasteful of coolant in the downstream parts unless the distribution of injected flow can be made non-uniform by controlling the porosity or by some other means. The most obvious applications of effusion cooling are to gas turbine blades and combustion chambers, rocket chambers, missiles, and other cases where the protecting of the surface from a hot gas enables a cheaper material or high gas temperature to be used, but it is essential

to have a supply of coolant and one criterion by which effusion cooling is judged against other methods is the amount of coolant needed. It is now generally agreed that for most of the applications mentioned effusion cooling through porous walls such as sintered metals is more economical of cooling air than other methods, such as internal blade air passages, especially if the distribution of coolant can be efficiently arranged, but the main reason why the method has not been used much so far is the decreased mechanical strength, both tensile and shock, of sintered metals and ceramics compared with metallic alloys. There is no fundamental reason why sintered metal should not have comparable mechanical strength to metals, and more will probably be heard of these methods in the future, perhaps as a means of cooling local hot spots rather than of cooling large areas.

A gas turbine combustion chamber with louvred walls through which cooling air is injected has been successfully used in the Auris gas turbine.

Radiation from Luminous Furnace Flames

The luminous flame, from which heat is radiated by small carbon particles produced by heating in a local deficiency of oxygen, is widely used in boilers and industrial furnaces, especially open-hearth steel-melting furnaces. The calculation of the heat radiated from such flames is extremely difficult because we do not know the number and size of the carbon particles at each position along the flame. The design of furnaces is often extremely critical, and a better control of flame radiation might well save a lot of money both in fuel consumption and in initial and maintenance cost. In the open-hearth steel melting furnace particularly, the refractory roof has to be renewed frequently, and anything which can be done to lengthen its life while maintaining or even improving the time of melting is of considerable economic value. Since radiation processes do not scale down directly, measurements must be made on flames of comparable size to actual furnace flames. The work of the International Flame Research Organisation at Ijmuiden, in Holland, has done much towards the solution of these problems by systematic measurements of radiating powers, temperatures, emissivities, &c., of flames from a variety of burners, conditions of air preheat, &c., with gaseous, liquid and solid fuels. The results so far indicate that for oil fuel diffusion flames—that is, oil flames in which the majority of the combustion air is entrained by the flame jet from its surroundings—the flame length is mainly determined by aerodynamic variables and particularly by the momentum of the inflowing jet, and may be studied by model techniques. The radiation distribution over the flame length is dependent mainly on the carbon-hydrogen ratio of the fuel and the initial rate of mixing of air and fuel at the burner. Near the burner the emissivity is high, often approaching unity, decreasing as the carbon burns away along the flame, but since the temperature tends to rise along the flame the actual radiation does not vary greatly along the flame length. Several results of practical value have emerged from these investigations, including the importance of the momentum of the burner jet and the effect of adding pitch creosote to flames of low radiation, such as coke oven gas flames, in order to increase their radiating power.

The flame problem is difficult to study because the radiation must be related back to variables, such as the burner design and arrangement, which are difficult to specify, the processes of combustion and heat transfer are mixed up in the flame. The only scientific method of approach to such a problem is to make systematic measurements to elucidate the mechanisms at work and so to find which variables have large effects and which have negligible effects.

In gas turbine combustion chambers, flame radiation has only a nuisance value, in that it necessitates more attention to cooling the walls by cold air or other means. Some recent work has shown that the type of flame stabilisers used in gas turbines give flames which radiate differently from diffusion flames. It is probable that the radiation from a luminous flame, unlike that from a non-luminous flame, is capable of control over wide limits by changing the burner design and arrangement even when the fuel and air remain the same.

Liquid Metals

The use of liquid metals for heat transfer has been brought to the forefront by nuclear reactor developments, since their high thermal conductivity makes them suitable for applications where very high heat transfer rates are required as in the fast neutron reactor. Moreover, in sodium and sodium-potassium euctectic alloy particularly, we have substances which do not capture neutrons wastefully and are therefore acceptable for reactors. The use of these substances, especially where water is likely to be present, seems at first sight to present formidable practical difficulties, but with the improvements in sealing and handling techniques which are in any case essential in dealing with nuclear appliances, these are no longer considered even serious. Prior to the nuclear application, the only liquid metal used was mercury, which has the disadvantage of toxicity. Heat transfer coefficients for liquid metals have now been extensively measured, but there is still some uncertainty in interpreting results which may be connected with the effects of thermal conduction in the direction of flow, which is negligible in non-metallic liquids. Liquid metals will probably be more widely used for heat transference in many industrial applications in the future, such, for example, as in steam reheating in power plant where they would enable the steam to be heated in heat exchangers close to the turbines. It is to be remembered, however, that liquid metals have relatively low specific heats compared with other liquids, which means that the weight of fluid necessary for a given heat removal may be high. The high temperature drops across the thickness of the walls of the tubes carrying liquid metal coolant may also become a critical factor, reaching as much as 500 deg. Fah. in 0·02in thickness of stainless steel tube wall, for a flux of 3,000,000 B.Th.U. per square foot per hour.

In this address I have mentioned only a few of the many kinds of heat transfer problems encountered by engineers and there has been no time to speak of many others such as boiling liquids, rotating bodies, and surfaces in contact. It seems that with the coming of new industries such as electronic, aircraft engineering, nuclear and chemical engineering, quite new kinds of heat transfer problems arise, or at any rate unexpected developments of old problems, with the result that the scientists and engineers are trying to solve new problems and consolidate the background of the subject at the same time. However, an immense amount of theoretical and experimental effort is now being put into heat transfer research to-day, especially in the U.S.A., and the recent words of H. L. Dryden, Director of the National Advisory Committee for Aeronautics, may well be quoted :

" Creative research, inventive development, inspired design and novel construction in the field of heat transfer—all must be accelerated on a broad front to keep pace with the needs of modern technology. Nuclear reactors, rocket engines, high-speed ballistic missiles re-entering the atmosphere, and certain types of chemical engineering equipment encounter extreme conditions of temperature and rate of heat transfer, challenging scientists and engineers to explore new problems and ranges of parameters."

Theoretical methods have greatly contributed to advancing our knowledge in the last quarter of a century, and will continue to do so, but I should like to conclude by making a plea for more experimental work. This can be of two kinds. First, we need careful experiments under controlled conditions, to evaluate physical properties and the experimental constants of phenomena such as turbulent convection. Secondly, we need more experimental observation of what is happening in actual appliances. In heat transfer experimental measurements are not easy, and there are plenty of opportunities awaiting the young research physicist and engineer.

Studies of Arch Dams and other Problems at Lisbon

The Laboratorio Nacional de Engenharia Civil at Lisbon in Portugal, which is directed by Manuel Rocha, has just published thirteen reports on recent work carried out there. Eight of these reports are in English, three in French, and two in Portuguese.

The bulk of this work concerns recent Portuguese dams, seven of the reports being on researches into the design and behaviour of dams. A general study of six Portuguese arch dams, ranging in height from 60m to 135m, is reprinted from the American Society of Civil Engineers' *Journal*, since it was first presented at the A.S.C.E. symposium on arch dams held at Knoxsville in 1956. The study concentrates on two aspects—model testing for design, and observations in the field of the completed structures. This correlation of model analysis and full-scale observation has enabled later designs to be modified to gain increased economy with safety. The five dams treated in this way are Castelo-do-Bode, Venda Nova, Cabril, Salamonde, Bouca and Canicada.

An original paper in Portuguese describes a method of computing temperature variations in a concrete dam, after all the heat of hydration has been lost. The remaining studies concerned with dams are reprints of papers presented at the 1955 Rilem symposium in Lisbon, and describe the measurements of strains, absolute displacements and joint movements in large dams ; a résumé of the methods and apparatus used in such work is given in one paper.

Other papers reprinted from the Rilem symposium concern problems in precise levelling, stress and strain measurement of some reinforced concrete structures, principally bridges, apparatus for measuring displacements in slopes and embankments, and an evaluation of the safety of various steel bridges built over sixty years ago. Finally, there are two original papers, one, in French, deals with applications of radio-isotopes in civil engineering, and gives an example of such application, namely, the use of a tracer to study the movement of sand on the sea bed. The second, in Portuguese, is a review of the clay industry in Portugal, development of which, it is contended, is not receiving sufficient interest.

International Astronautical Congress

NEARLY a year ago members of the world's astronautical societies met together in Barcelona as "Sputnik I" was making its first few orbits around the earth. It had been hoped that when they reassembled in Amsterdam at the end of last month that the first lunar probe would have accomplished its mission successfully, but that was not to be. As it happened, it was news of another Russian achievement which was announced —the safe recovery of two dogs from a rocket flight to a height of 250 miles, apparently without the use of parachutes. However, Russian scientists attending the Ninth International Astronautical Congress at the University of Amsterdam, August 25–30, thought that the publicity given to the achievement in the press was unwarranted. To them it was just another successful biological experiment and only the establishment of the first manned satellite would be regarded as a great step forward.

Nevertheless, the past year has seen many advances in the field of astronautics and a great increase in the effort being devoted to space research. This was reflected in the number of papers (over eighty) presented to the scientific sessions of the Congress, which was double that given at Barcelona, so that parallel lecture sessions were needed. If this tendency continues, the Congress will become too big to be held within a single week; many participants were already regretting that the parallel sessions prevented them from attending all the papers in which they were interested, and this difficulty was made worse by last-minute changes in timetable. A partial solution would be to fix a much higher standard for the acceptance of contributions, which in this case ranged from the excellent to the trivial. Unfortunately, in international meetings of this kind, the inclusion of one or more papers is often a matter of national prestige.

One of the two series of lecture sessions was devoted entirely to propulsion systems and propellants. G. V. R. Rao, of the Rocketdyne Division of North American Aviation, Inc., presented a method of designing rocket nozzle wall contours to give optimum thrust. E. Büchner gave performance data for various liquid and solid propellants. J. Corbeau and C. Diol made a mathematical study of the effect of various factors (rate of injection, turbulence, degree of atomisation, chamber dimensions) on the combustion of fuel droplets in a rocket combustion chamber. E. W. Price, of the U.S. Naval Ordnance Test Station, discussed combustion instability in solid propellant rocket motors and means for its detection. The low-frequency mode of pressure oscillation sometimes found in liquid-propellant motors is rarely, if ever, found in "solids," where oscillation frequencies of the order of 3000–50,000 c/s are observed. Instability can be suppressed by suitable nozzle design or by inclusion of suspended particles (introduced as additives in the propellant) in the gas flow. Some promising work has been done with additives such as carbon, aluminium and aluminium oxide.

J. A. Vandenkerckhove dealt with the mathematics of designing an optimum solid propellant rocket, and Monsieur Serruys with the importance of thermodynamics in evaluating rocket performance possibilities. H. Itokawa briefly described the development of the "Kappa" upper atmosphere sounding rocket for the Institute of Industrial Science of the University of Tokyo, and his talk was illustrated with a colour cine-film. The rocket was developed in connection with the International Geophysical Year, a basic study on solid-propellant two-stage rockets ("Pencil" and "Baby") being carried out in 1955. Single-stage "Kappa" rockets were fired in 1956, and two-stage "Kappas" in 1957. The first sounding flight took place on June 30, 1958, using a type 6 "Kappa"; the maximum altitude attained was 70km, and the maximum speed Mach 5·5. It is hoped that a type 7 "Kappa" now being developed will reach 100km altitude. Mr. Itokawa said that the programme is being carried out by volunteers; the film showed their equipment for constructing the rockets, carrying out static tests, launching and tracking, &c. It is understood that the Japanese military authorities are now interested in these rockets.

But the main emphasis was on more advanced systems of propulsion, and this was evident even at the official opening of the Congress, when Theodore von Kármán gave an address on magnetofluidmechanics, the term he preferred for the new branch of science often known as magnetohydrodynamics, or by other names. This finds applications not only in attempts to produce thermonuclear power, but also with such propulsion systems as the ion rocket and electromagnetic ramjet, and with flight in the atmosphere at hypersonic speeds, e.g. during re-entry.

Dr. L. R. Shepherd, of the Atomic Energy Research Establishment, Harwell (Chairman of the British Interplanetary Society), reviewed possible electric propulsion systems, and favoured the use of a closed-cycle plasma generator coupled to a magnetic plasma accelerator. Electric propulsion develops only low thrusts and is not suitable for taking-off from the earth and similar planets, but if the engines could be taken up or assembled in space, they would be suitable for journeys out from satellite orbits. While these systems are not of immediate importance in astronautics, there is a current U.S. research project ("Snooper") for a lightweight electric propulsion unit small enough to be projected into an orbit by existing vehicles. Various American firms are engaged in the necessary preliminary research and development work.

Five physicists from the Research and Advanced Development Division of Avco Manufacturing Corporation, Lawrence, Mass, described their experiments in generating plasma with fluids-stabilised arcs. Both gas and water-stabilisation have been examined and the latter is considered superior; temperatures and specific impulse are higher, but the mass flow is less. Considerable information has been obtained on arcs of high power (25kW to 500kW). The fraction of input electrical energy converted into gas enthalpy is of the order of 50 to 70 per cent. The main problem in actually using plasma generators for propulsion is primarily one of scaling and of finding a power package small enough to be lifted into a satellite orbit.

W. H. Bostick, of the Stevens Institute of Technology, Hoboken, New Jersey, was concerned not with generation but with the magnetic acceleration of plasma, and he analysed four possible types of accelerator. Both theory and experiment indicated that velocities of 2×10^7 centimetres per second (specific impulses of 2×10^4 seconds) could readily be produced, and that with improvements in technique velocities of 10^8 centimetres per second might be attainable. H. Bednarczyk (Austria) also discussed magnetic acceleration.

Another propulsive method employing plasma, but one even further removed from present possibilities, was suggested by B. Karlovitz and B. Lewis, of Combustion and Explosives Research Inc. They thought that it might be possible to ionise interstellar gas ahead of the vehicle by using high-voltage electron beams and then accelerating the ionised gas mass by the electromagnetic field system of the vehicle. This would presuppose that a large output of electric power was available, e.g. from a thermonuclear generator. Electric power requirements for various types of vehicle were investigated by J. H. Huth; scientific satellites would not require more than about 100W and this could be provided by batteries, solar cells or possible by radioisotope units. Electrical propulsion and manned spacecraft would necessitate the provision of several megawatts, from either nuclear or solar sources.

In a discussion of "trans-conventional" propulsion systems, G. C. Szego, of the General Electric Company, U.S.A., reached the conclusion that the metastable states of helium and neon were the only free radicals which might be attractive energy sources for propulsion. J. Hilsenrath, M. S. Green and C. W. Beckett, of the U.S. National Bureau of Standards, gave a method for computing certain thermodynamic properties of gases and gas mixtures containing atoms and ions in equilibrium. Typical results were given for oxygen, nitrogen and air at 25,000 deg. to 2,000,000 deg. K.

Eugen Sänger, a former President of the I.A.F., had studied in detail the conditions under which the use of a stream of photons for reaction propulsion could compete successfully with other systems. His wife, Irene Sänger-Bredt, contributed a systematic review of the various possible rocket types and presented thermodynamic data for the hydrogen-oxygen system. W. Peschka considered the use of atomic hydrogen as a fuel for liquid-propellant rockets.

Among the subjects other than propulsion, artificial satellites naturally occupied a prominent place. Three Russian papers were concerned with their "Sputniks": K. F. Ogorodnikov told how the Soviet visual and photographic observation stations were organised and equipped, L. I. Sedov reported on the orbits of the three "Sputniks" and the deduced values of the atmospheric density, V. I. Krassovskii gave a more detailed account of the geophysical investigations made with the help of "Sputnik III." In general, the Russian results were in agreement with those obtained by America and Britain.

The techniques used here for analysing radio and optical observations of artificial satellites were summarised by R. H. Merson, of the Royal Aircraft Establishment, Farnborough, who also gave preliminary results of the analysis of "Sputnik II" observations. The theoretical and observed values of the rate of rotation of the orbital plane differ by 0·7 per cent, and this indicates the possibility of improving the accepted values for the coefficients in the formula for the earth's gravitational potential field. Another British contribution was by T. R. F. Nonweiler, a lecturer in Aeronautical Engineering at the Queen's University of Belfast, who has already published several papers on re-entry problems. In a study of the motion of an earth satellite during that part of re-entry where aerodynamic forces predominate he demonstrated that the motion was relatively

insensitive to the form of orbit previously described, provided a sufficiently large number of circuits had been made. The retardation suffered was also independent of the size, shape and weight of the satellite—these factors merely determined the height at which retardation occurred.

Those attending the Congress were naturally looking forward to hearing Dr. Wernher von Braun, Director of the Development Operations Division of the U.S. Army Ballistic Missile Agency at Redstone Arsenal, Huntsville, Alabama (and formerly in charge of the development of the "V.2" missile at Peenemunde), speak on the American "Explorer" launching vehicles. However, his paper had to be postponed on several occasions and was not given until the last day of the Congress, as he injured his back in stooping to pick up a piece of paper and was confined to bed in case he had a slipped disc. When he was able to appear, he gave an interesting account of the construction and launching of "Explorer" (THE ENGINEER, September 5, page 372) and revealed that "Explorer V" had failed through the burnt-out first stage running into the rear of the remainder of the rocket during a coasting period.

The scientific results obtained from the "Explorer" satellites were reported by A. R. Hibbs, of the California Institute of Technology, and also by Dr. James van Allen and others of the Iowa State University. The latter paper dealt solely with the radiation measurements from "Explorer IV." At altitudes above 1000km there is a belt of high-intensity radiation. This varied both in quantity and quality with latitude and altitude. A low-energy component was usually present, but the number of high-energy particles increased as the magnetic equator was approached.

Professor S. F. Singer, of the University of Maryland, has developed a most ingenious theory which explains the origin of this belt. Actually, it was developed in connection with a new theory of magnetic storms and auroræ, but its results are compatible with the data from "Explorer IV." Neutrons produced by interaction of cosmic rays with the atmosphere undergo radioactive decay into protons. A minute proportion become "trapped" by the earth's magnetic field, and then move backwards and forwards from pole to pole in a spiral movement around the lines of force. This motion can continue almost indefinitely, so that over millions of years a minute increment of particles has built up into the intense field discovered by "Explorer" satellites. The theory indicates that the field stretches from 250 miles to 40,000 miles above the earth's surface, with a maximum at about 6000 miles altitude. Important deductions are that manned satellite flight is not likely to be permissible above 250 miles altitude, unless it is possible to build into the ship either "shadow screening" (the weight penalty for complete screening is prohibitive) or electromagnetic screening; that escape into space is possible near the magnetic poles (where the radiation belt should be absent); and that it should not be too difficult to sweep away the belt by absorption in artificial satellites (the low rate of build-up means that the belt would not be restored within the foreseeable future). This is the only explanation for the radiation that can be advanced at present; Professor Singer has suggested that his theory could be confirmed by sending a small electron accelerator up in a satellite to produce an artificial "trapped field."

Among the other papers concerned with satellites, mention can be made of that by R. E. Roberson, of North American Aviation Inc., which was a mathematical analysis of the classical proposal for controlling the attitude of a space vehicle by internal rotating masses. Fred L. Whipple (director of the Smithsonian Astrophysical Observatory) put forward a plan for establishing an orbital astronomical telescope which would be provided with an electronic scanning system so that the image could be transmitted to a ground station.

Bryan R. Noton, a consulting engineer in Sweden, stressed the advantage of using composite or sandwich structures for vehicle construction; work is in progress on honeycomb cores and panels in silicone plastics, titanium, Inconel X, and other elevated temperature materials. Foamed ceramic cores have also been produced.

R. P. Haviland, of the U.S. General Electric Company, suggested that although the present state of rocketry limits the distance of closest approach to the sun to about the orbit of Mercury, available components would permit the design of a probe capable of reaching within 5,000,000 miles of the solar surface. Some of the considerations involved in the design of a solar probe were discussed—component temperatures, stabilisation, telemetry, instrumentation, &c.

Astronautics is more immediately concerned with lunar, rather than solar, probes. The launching failure of the first U.S. attempt to reach the moon has left us still in ignorance as to whether present techniques of guidance and control are sufficiently precise for this task. A purely ballistic trajectory is desirable, but it may be necessary for a mid-course correction to be applied. M. W. Hunter, W. B. Klemperer and R. J. Gunkel (Douglas Aircraft Company) have studied the problem of applying a corrective impulse, and their paper commented on both the approximate two-dimensional solution and the more accurate three-dimensional one. In one example given, the use of such an impulse increased the angular tolerance in initial flight path angle from ± 3 to ± 9 milliradians.

Other papers concerned with orbits and navigation included "Accuracy Requirements for Interplanetary Ballistic Trajectories," by T. A. Magness, J. B. McGuire and O. K. Smith (Ramo-Wooldridge Corporation; emphasis on the Earth-Mars and Earth-Venus shots); "General Variational Theory of the Flight Paths of Rocket-Powered Aircraft, Missiles and Satellite Carriers," by Professor Angelo Miele (Purdue University); "An Interplanetary Navigation System," by E. V. Stearns (Lockheed Missile Systems Division; the Earth-Venus journey was selected for specific discussion); and "Interplanetary Trajectories with Excess Energy," by W. E. Moecjel (NACA Lewis Flight Propulsion Laboratory; several families of interplanetary trajectories analysed).

A large sector of American industry is now working in the astronautics field, as is evident from the firms mentioned above and from the list of persons registering for the Congress. Indeed, the stage has now been reached when some U.S. firms are unable to carry out all the work which they would like to do. Their representatives at the Congress were seeking European organisations to whom they could allocate research contracts.

In addition to the scientific sessions a colloquium on the law of space was held in the Rolzaal (Hall of Knights) at the Binnenhof (Parliament Buildings), at The Hague. It was concerned with such questions as the liability for damage to aircraft or other property resulting from satellite or rocket experiments, the interference of satellite radio transmissions with ordinary telecommunications, &c. A resolution was passed that a new international convention should settle the legal problems involved in the development of astronautics, that an International Astronautical Federation legal committee should be established, and that the United Nations should be informed of the willingness of the I.A.F. to co-operate in any action in the field of astronautics.

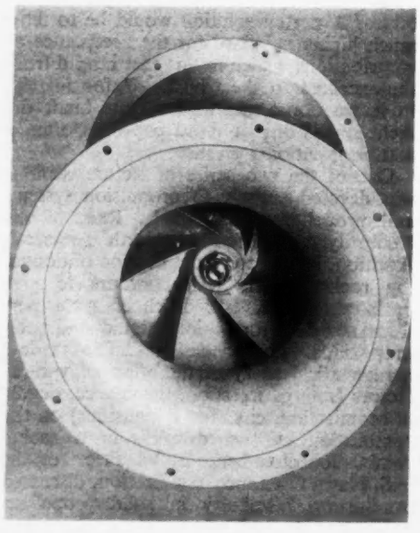
Mr. Andrew G. Haley (an American lawyer specialising in telecommunications and air law) was re-elected president of the I.A.F. As the U.S.S.R. has found it impossible to hold the 1959 Congress in Moscow because of inadequate hotel accommodation, it was decided that the next Congress should be organised by the British Interplanetary Society in London, September 14 to 19, 1959.

During the Congress discussions were held among the representatives of the various Commonwealth astronautical societies present. It was agreed to promote the formation of similar societies in Australasia and Rhodesia, and to organise a joint Commonwealth meeting in London immediately before the next I.A.F. Congress.

Compound Flow Fan

WE illustrate a new fan developed by Keith Blackman, Ltd., Mill Mead Road, London, N.17, which is known as the "Ax-Cent" compound flow fan. It is said to combine the advantages of both the basic axial and centrifugal designs of fan, being similar in external appearance to an axial fan yet possessing centrifugal fan characteristics.

The fan differs from the conventional axial design in that its cylindrical casing contains a venturi type inlet to a shrouded, compound flow impeller followed by guide vanes. The maker



Inlet end of "Ax-Cent" fan, showing venturi design inlet to the shrouded, compound flow impeller

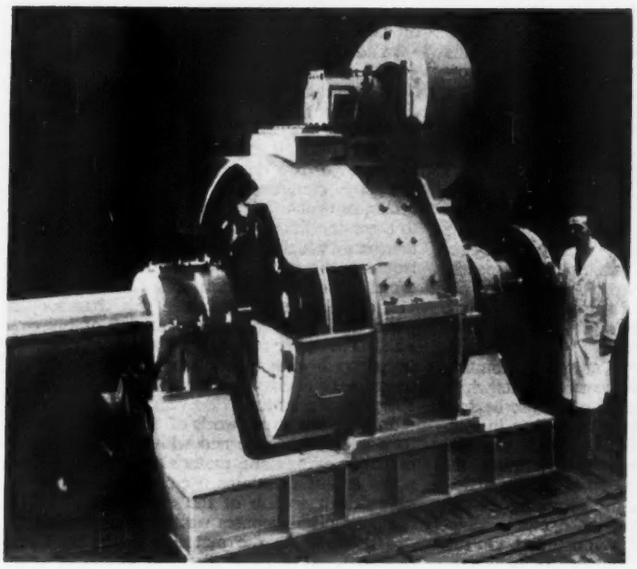
states that with its steep pressure/volume characteristic the fan contrasts sharply with the normal axial type because as a single-stage unit it provides twice the pressure development of the single-stage axial fan running at the same speed, its pressure/volume being more comparable with a two-stage axial type fan. The mechanical efficiency and relatively low sound level of the new fan is said to compare very favourably with that of a centrifugal fan for equal duty.

The "Ax-Cent" fan can be used for higher pressure duties with an acceptable sound level which has hitherto necessitated a centrifugal fan; in cases where the centrifugal type is difficult to accommodate because of equipment or duct layout, or because of restrictions of available space.

Shaft Generator for Motor Tankers

AN interesting arrangement for taking auxiliary power supplies from a ship's main engines is illustrated here ; it consists of a direct current generator built around the intermediate propeller shaft. This equipment has been designed and made by W. H. Allen, Sons and Co., Ltd., Bedford, for installation in the motor tankers "London Majesty" and "London Victory," owned by London and Overseas Freighters, Ltd.

Five main requirements for this shaft generator were specified by the tanker owner. First, that the generator should be built as a part of the intermediate propeller shaft without any welding on the shaft, the flange at each end being forged integral with the shaft. Secondly, that the generator should give its output of 150kW at 110V at a constant voltage over the speed range of 80/126 r.p.m. Thirdly, that the voltage should remain sensibly constant over the foregoing speed range. Fourthly, that the excitation should come from an independent 110V d.c. source. Fifthly, that the machines should be watertight up to the underside of the shaft.



150kW, 110V, shaft generator for motor tanker "London Majesty." Because of the slow shaft speed (about 80 to 125 r.p.m.), the generator is force-cooled by a motor-driven fan mounted on the frame at the driving end

In meeting this specification, the major difficulties faced were those associated with cyclic irregularity of engine speed, particularly under seagoing conditions ; steady and transient voltage control ; relative movement of the ship's structure ; shaft currents, and maintenance of the generator. The main points of interest about the design are summarised here.

Except for that part of the shaft carrying the commutator and armature, the generator shaft conforms exactly to the design and proportions of the existing intermediate propeller shaft. The part of the shaft that carries the commutator and armature is forged up to a diameter greater than the couplings. Longitudinal ventilating ducts are ploughed out of this increased diameter, forming arms to which the core discs are keyed by means of tapered keys. Solid forged couplings (as on the intermediate propeller shaft) are incorporated in the generator shaft. The commutator is designed to be withdrawn over the coupling if required.

To provide constant voltage at any ship speed, the generator is designed so that it will generate normal voltage when running at any speed between 80 and 126 r.p.m., the voltage being automatically controlled by a Brown-Boveri automatic voltage regulator. The time constant of the shunt coils and the automatic voltage regulator is such that there should be no appreciable flicker under bad weather conditions.

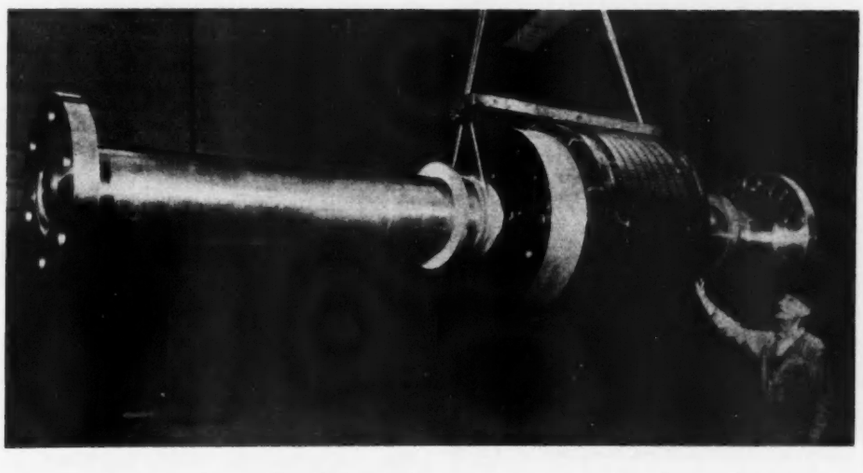
The magnet frame and pedestal bearings are secured by fitted bolts to a substantial bedplate which, together with the pedestal bearings, were designed, manufactured and installed by the North Eastern Marine Engineering Company, Ltd., who had previously built and installed the main machinery for the two tankers, "London Majesty" and "London Victory."

The generator has an unusually large air gap, to provide a margin of safety and avoid the damage that would result from exceptional wear in the bearings, each of which is fitted with a wear-down gauge for checking the amount of wear. Special attention was given to the design of the connections with the aim of eliminating any magnetic field around the shaft. Nevertheless, to short-circuit any stray currents and prevent electrolytic action, either within the ship's structure or the main engine bearings, two special-quality brushes, capable of running on an oily steel shaft, are provided at each end of the machine, the brushes being earthed directly to the ship. The commutator end bracket is designed to take a commutator grinder, so that truing-up can be carried out when necessary with the minimum of inconvenience. The main poles and interpoles are detachable and can be withdrawn from the driving end.

Because of the water which is often present in the tail-shaft compartment of the ship, the generator is of watertight construction to the underside of the shaft. Heaters are fitted in the bottom of the commutator end plate to keep the temperature above ambient and so prevent condensation within the machine when it is out of use.

Because of its slow speed, the machine is force-ventilated by a separate motor-driven fan at the driving end, designed to provide the required quantity of cooling air when the machine is running at 80 r.p.m. A filter is fitted in the air trunking for removing oily vapour, and the direction of air flow is such that the carbon dust is blown away from the commutator and windings.

Audible alarms are installed to operate in the event of failure of the ventilating motor, or a drop in voltage below 110V caused by the speed falling to well below 80 r.p.m., or the engine stopping. No difficulties are anticipated when the engine is reversed.



The commutator and armature of the 150kW generator are built around the ship's intermediate propeller shaft which has a solid forged coupling at each end

Argentine Iron and Steel Works

IT is announced that a contract has been signed between the Zapla iron and steel works, which is administered by the Dirección General de Fabricaciones Militares, and the German firm Demag, of Duisburg. The latter is to supply blast-furnace equipment and complete installations for a steel works and rolling mill plant. As far back as 1953, an agreement for consultant services was concluded between the Zapla works and Demag, covering the modernisation and extension of the existing blast-furnace plant at Argentina's first integrated iron and steel works, which was to use native raw material resources for its production processes. The site for the works is 1800km from Buenos Aires, in Jujuy Province, near the Bolivian frontier, and the great Sierra de Zapla mountain range. The project envisages the gradual replacement of the two blast-furnaces with a daily output of 60 tons by four blast-furnaces with a daily unit output of 125 to 150 tons. Whereas hitherto the annual output of 35,000 to 40,000 tons of foundry iron produced was despatched by the works to other concerns in Argentina, the future annual output of roughly 165,000 tons of blast-furnace metal will, for the main part, be processed in a combined basic Bessemer and electric steel shop.

The steel works will have three 15-ton converters and a 20-ton electric-arc furnace with a combined annual output of 140,000–150,000 tons of ingot steel.

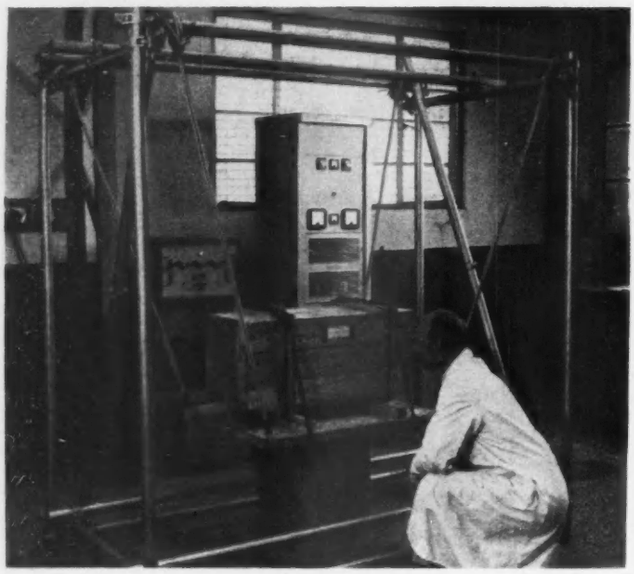
In the initial stage of development of the Zapla works the steel will be further processed in a 720mm three-high blooming mill and a 475mm three-high medium-section mill with an annual output of 120,000 tons of sections varying from $\frac{3}{4}$in upwards to 4in. When all rolling mill facilities have been finally installed, a light-section and wire-rod mill will be included in the plant.

The raw materials used by the works are in the immediate vicinity, ore being mined in the Sierra de Zapla. Metallurgical fuel in the form of charcoal comes from eucalyptus trees specially grown in huge plantations to meet the plant's demands. Hitherto, the wood has been burned to charcoal in the old charcoal-pile process, but the project envisages a complete wood carbonisation plant which will produce up to 75 per cent of the charcoal needed for the blast-furnaces. The top gas generated in the blast-furnaces and the combustible by-products from the wood-carbonisation plant will be used to produce electric power for the works.

SHORTER REPORTS

Packaging Research Laboratory

THE packing of goods for transport and storage under different climatic conditions has for several years been recognised by all branches of industry to be of particular economic importance, especially where fragile parts, delicate instruments, high precision equipment and machines have to be exported. To provide the necessary protection against the effects of impact, vibration and corrosion in transport and storage many materials and techniques have been developed, and much knowledge acquired in their application by firms specialising in packing. One such specialist firm is Geo. Salter and Co., Ltd., of West Bromwich, the makers of springs and spring balances. This firm, some ten years ago, set up a small pre-packing department for its own products and proceeded to develop techniques which would ensure that goods exported or stored for long periods would be unaffected by extreme climatic conditions and survive transport. This department had to be extended as other companies sought assistance with their packaging problems, and eventually a new "Salterpak" Division was set up for this specialised work and housed in large premises in Spring Road, Smethwick.



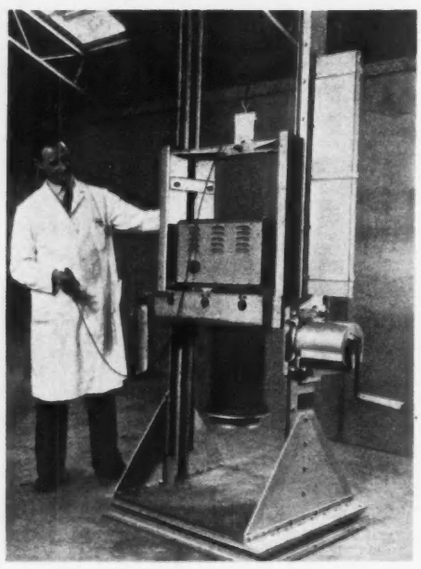
Vibration tester for packaged equipment

An essential part of the work of a department which is called upon to solve a wide range of individual as well as bulk packing problems is a research and testing laboratory, and during a recent visit to the Salterpak laboratory we were given an opportunity to see the range of testing equipment which has been installed. This laboratory is equipped to simulate all kinds of hazards to which a package may be subjected, from tropical rains to equatorial heat and from crushing to dropping from different heights.

Using electronic instruments in conjunction with testing machines it is possible for the laboratory to make accurate assessments of the various hazards encountered by packed goods in transport and handling, so that special provision can be made to ensure their safe arrival. In a drop test the contents of a case are connected to an accelerometer, and after the case has been raised to a predetermined level it is dropped freely. The deceleration on the contents of the case are recorded, and from this data the correct cushioning materials and technique required to give the goods full protection can be determined. To simulate the jolting a package would receive when being carried in a vehicle on bad road surfaces a "bumping" machine is used. On the table of this machine cases can be bumped with a free drop of 1in at a rate of four times a second.

Vibration during transport can be particularly detrimental to delicate instruments and equipment and to explore a range of frequencies which is likely to be damaging to the goods packed a special electronic vibrating table rig has been installed. On this machine the frequency range of a product can be explored between 3 and 1000 c/s, at an amplitude variable within the limits of the force-mass-frequency relationship of any specific test set-up. Before designing a suitable packing it is thus possible to determine the natural vibration frequency of parts which might otherwise be self-destroying when in transit. Another machine used to determine the properties of an article before packing is the fragility factor equipment illustrated. On this machine the article to be packed is elevated to a predetermined height on a table fitted with an air cushioned bumper on its underside. When the table drops with the article fastened on its surface instruments record the precise amount of force to which they are subjected. With this rig, if required, the "G" factor safety limit can be established, so that an efficient pack can be evolved without unnecessary precautions in overpacking.

A not infrequent cause of damage to cased goods is the inadvertent swinging of a case slung from a crane against a dockside. An impact test has been developed to simulate this effect on packing cases. For it a 29ft long section of railway line has been laid on a 10 deg. incline with a solid concrete block at the lower end. Cases for test are placed on a wagon at the top of the incline and the wagon allowed to run freely down the incline. A rigorous test on the strength of the case is imposed when it is brought to a sudden halt from a speed of about 10 m.p.h. on contact with the concrete block.



Fragility factor testing equipment

In addition to the physical testing of packaged goods in transport and handling, problems of storage under all climatic conditions are studied. For tropical humidity tests there has been installed in the laboratory a special chamber in which packs are exposed to a temperature of 95 deg. to 100 deg. Fah. and 100 per cent humidity conditions. A series of complete cycles, in which the packs are repeatedly exposed to these conditions and cooled, expose any faults in a case which are likely to be revealed in a tropical climate. To simulate the effects of direct equatorial sun on packs a 22ft by 20ft by 11ft chamber is used, and in this chamber the packs are subjected to temperatures of 140 deg. Fah. The water resistant properties of cases are tested by hosing them with jets of water at a pressure of 60 lb per square inch and a rate of 100 gallons a minute.

In addition to its work of testing the laboratory is closely concerned with the development of new methods and materials for packing purposes and it maintains a close liaison with the case design section of the establishment. This design section prepares working drawings of all cases, specifying the materials to be used and their method of application. It should be noted that a service is maintained for preparing designs for cases and packings for other firm's own packing departments, and in such cases full tests can be carried out in these specialised laboratories.

Speed-Reduction Pulleys

A SPEED-REDUCING pulley introduced by Furnival and Co., Ltd., Reddish, Stockport, is being made in sixteen sizes to transmit drives of up to 80 h.p. It is a self-contained unit and the design, as can be seen in the accompanying illustration showing a cut-away pulley, is based upon a sun and planet gear system. In it a fixed sun wheel drives a second sun wheel coupled to the driven shaft through reduction planet pinions.

In order to overcome difficulties in equilibrating the load on the teeth experienced when more than one multiple gear train is disposed round central sun wheels, an assembly method which eliminates the use of steel keys and very high precision fitting has been developed for locating the planet pinions on their shafts. In this method the planet pinions are first freely mounted on their shafts so that they can assume a natural position for meshing with the respective sun wheels. Special adapter pieces are then used in place of the shaft bearings to form a sealed mould cavity into which heated nylon is injected in a special press to form keys through which the drive is transmitted. When the nylon has set the adapters are removed and replaced by the ball and roller bearings on which the shafts are mounted. With this form of assembly the slight degree of elasticity of the nylon allows the bearings to give the pinions a sufficient working clearance to distribute the load evenly upon them. Single helical gears are used throughout in the pulley and all rotating parts are carried on ball and roller bearings.

The necessary immobilisation of one of the sun wheels is effected by a torque arm consisting of a casting fitted with leaf springs and held by a stop. These sun wheel torque arm assemblies can be supplied, if required, to act as torque limiting devices or as clutches. These ancillary

Speed reduction pulley with case cut away to show the sun and planet gear system

devices form an integral part of the pulley assembly and can be arranged for remote or hand control to ensure positive predetermination of the working load. In the event of a pulley fitted with the standard torque arm being overloaded the springs are designed to fail. When a torque limiting fitting is supplied it can be arranged to shut off automatically the power or disengage the drive on an overload.

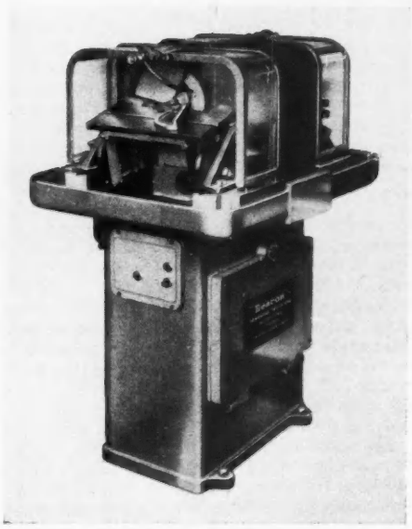
This "Andantex" range of speed reduction pulleys is available with twenty-one ratios, from 2·79 to 1 to 273 to 1, where the driving and driven shafts rotate in the same direction. When it is required for a driven shaft to rotate in the reverse direction the ratio range available is from 1·79 to 1 to 272 to 1.

Tool Grinding and Lapping Machine

We illustrate a carbide tool grinding and lapping machine with two 8in diameter wheels made by Beacon Machine Tools, Ltd., Hurst Lane, Tipton, Staffs. The main spindle of the machine is driven through a vee belt by a continuously rated reversing 1½ h.p. motor at 2600 r.p.m., which gives a peripheral wheel speed of 5400 s.f.p.m.

At each wheel the machine is fitted with a 16in by 8½in table which can be adjusted to give from 10 deg. negative to 30 deg. positive rake. A protractor tool rest is located in a dove-tailed slot in the table, and the table top, which is adjustable for wear, is designed to suit all shapes of tools up to 2in depth of section. During grinding or lapping operations the table can be oscillated by hand over an adjustable stroke up to ⅛in between stops.

Coolant is supplied by a built-in motor-driven pump and the large anti-splash guards fitted are of transparent plastic on aluminium frames. Wheel guards of swing-over design enable right or left-hand working during grinding or lapping tools.



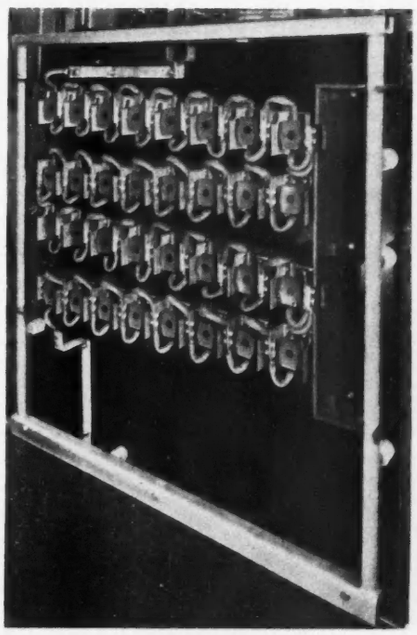
Tool grinding and lapping machine with oscillating table and suitable for positive or negative rake grinding of tools

Silicon Rectifier for Railway Traction

We learn from the British Thomson-Houston Company, Ltd., Rugby, that the first silicon power rectifier to be used to convert electric power for traction service in Great Britain has been installed experimentally in a motor-coach on the Lancaster–Morecambe–Heysham line of British Railways (London Midland Region). While this line is in public service it has, since its re-equipment on the 50 c/s system, been used by the British Transport Commission as a testing ground for new traction equipment. The installation of this B.T.H. silicon rectifier represents a contribution by British Railways to the development of single-phase a.c. traction at industrial frequency.

The coach in which the silicon rectifier has been installed has been operating successfully since December, 1955, with an equipment using germanium cells, also of B.T.H. manufacture, and this rectifier has now been removed to make room for the new equipment which consists of the latest type of B.T.H. silicon cells.

Whereas the original rectifier consisted of 600 germanium cells, the new rectifier embodies only



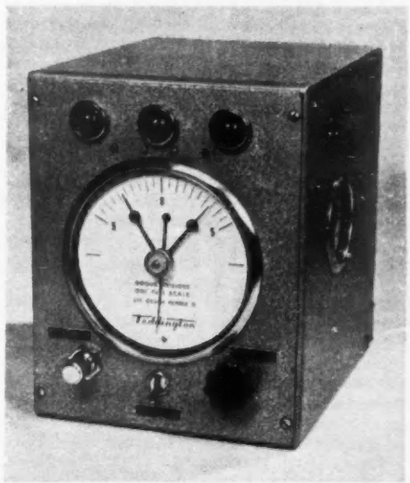
Tray of B.T.H. silicon power rectifier in service on motor coach on British Railways Lancaster-Morecambe-Heysham line, electrified at 50 c/s, single phase

192 silicon cells of comparable unit size, which makes a substantial saving in size. The rectifier consists of six trays (one of which is illustrated here) each carrying thirty-two air-cooled silicon cells. Compared with the germanium rectifier there is a substantial saving in size and weight. The silicon cell can also operate safely at a considerably higher temperature than is permissible with a germanium cell. Silicon power cells are being produced at a new plant in the B.T.H. Rugby works where germanium power cells are now in quantity production.

Pneumatic Size Control Equipment

A pneumatic size control equipment manufactured by Teddington Industrial Equipment, Ltd., Sunbury-on-Thames, is designed to provide a completely flexible control for grinding, fine turning and other manufacturing processes. The complete equipment comprises two units—a gauging head which is fixed to the machine and transmits a pneumatic signal to a separate control unit. This control unit, illustrated herewith, houses all the pneumatic and electrical components for the measurement and control of size.

The signal from the gauging head operates pneumatic/electric relays which in turn operate electric relays, each of which has a pair of change-over contacts. These contacts are wired



Control unit of pneumatic size control equipment for machine tools

to the machine controls to provide the required control action. Either two or four output relays are provided and each relay is adjustable and can be set to operate at any point in the range of the instrument. On a grinding machine controlled by the equipment, the work cycle could commence with a coarse feed changing to a slower feed at a predetermined point with a wheel dressing operation initiated where required and finally spark out to size. The final relay could be set at the lower tolerance limit to prevent out of tolerance parts being produced. Three light signals are provided which operate in sequence with the relays, red first at over-size followed by amber and green then amber again and finally red.

The equipment has an adjustable amplification and may be used for any full-scale range from 0·001in to 0·004in; for special applications, lower amplifications can be provided. The pneumatic/electric relays incorporated in the control unit are of a new design and are stated to be so sensitive that when used with the highest amplification (5000) they will operate on a size change of less than 0·000005in.

The three standard gauge heads available are each adjustable over a wide range of sizes. For external grinding between centres an external caliper gauge is used and mounted on the wheel shield. The caliper is adjustable and by using interchangeable jaws a size range of ½in to 6in diameter may be covered. For through-feed centreless grinding a "post process" gauge is used with a gauge head mounted to check components as they leave the work rest. Where the parts leave the machine in a continuous stream, an adjustable trend gauging head is used. Two sizes of these heads are available, one covering ¼in to 1¼in outside diameter, the other from 1¼in to 3in outside diameter.

When the parts leave a machine at intervals or where the surfaces of the work are interrupted by flats or under-cuts, timed gauging is used. This method ensures that control signals are fed to the machine when a workpiece, or a full diameter section of the work is in the gauging position.

Truck and Tyre Evolution

THE normal control vehicles of the Bedford range have been revised. The vehicles now range up to 7-ton trucks and an 8-ton tractor : the smaller vehicles, up to the 4-ton truck, use 7·50×16 tyres of ply ratings up to 10 instead of 20in wheels. The use of smaller tyres not only gives more choice of platform height, but allows the 200 cubic inch instead of the 300 cubic inch diesel to be used in the 4-tonner without resort to a double-reduction axle, and, it is claimed, will result in an overall reduction of tyre costs. The smaller wheel and smaller brake that goes with it result in a lower unsprung weight, which improves the environment of the tyre when the vehicle is empty, and, together with the change in final drive ratio, save as much as 600 lb in vehicle weight. Apart from these secondary effects, however, it has been shown that the newly designed types of at least one make improve in gross ton-mile life on the same make of 20in tyre. The gross vehicle weight of the 4-ton vehicle with 14ft body is 15,000 lb, the front axle rating being 4000 lb and the rear 11,400 lb, nominally 2850 lb per tyre.

All the vehicles have the same cabs, in which the near-side seat is wide enough for two to sit on. The overall widths are 7ft ±2in, but the vehicles with 16in wheels, such as that illustrated, have front wings that do not project beyond the cab step laterally (79½in), whereas the bigger vehicles have wider wings protected by a wrap-round bumper 80½in wide. All the standard bodies are built up clear of the chassis on pillars.

The design of a 7-ton vehicle in the normal control configuration has raised the maximum rear axle loading to 18,000 lb, and the Bedford two-speed axle has been redesigned to carry this load : the new, stronger, axle is used also on the forward-control vehicles.

The Bedford gearbox with synchromesh on the higher ratios is used in close-ratio form on the vehicles with the highest power-weight ratios (25 cwt and 35 cwt with 200 and 214 cubic inch engines, 5 ton with 300 cubic inch engines) and on the 7-ton vehicles, which invariably have the two-speed axle. The David Brown five-speed box is optional on all the 300 cubic inch vehicles.

On the 25 cwt and 35 cwt chassis (the latter is the only vehicle using more than one type of tyre, 7·50×16, six-ply, front, and 8·25×16, twelve-ply, rear) there are available van bodies, that by Spurling having a heavily curved two-pane windscreen to diminish the effect of the restrictions on provision of windows in Great Britain.

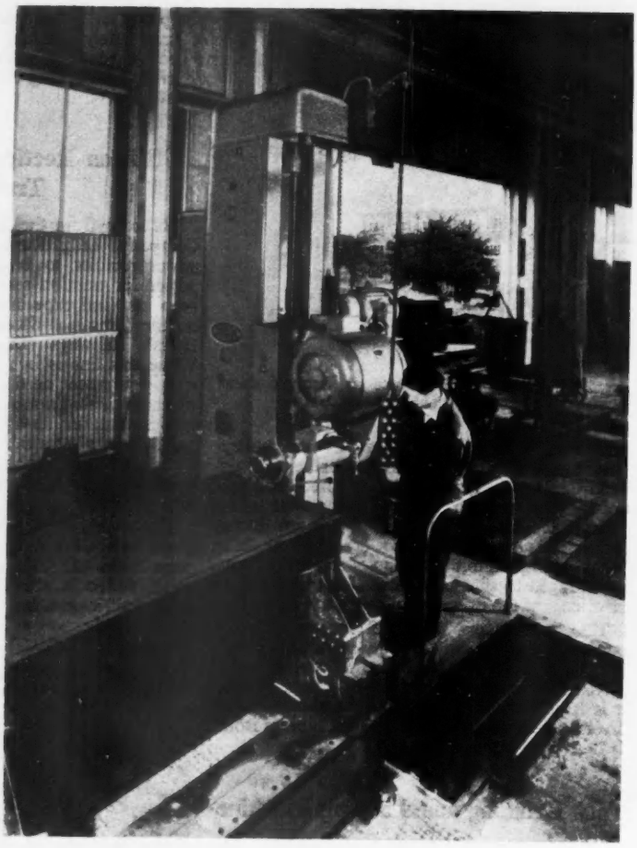
Girder End Facing Machine

IN structural engineering shops concerned with the preparation of girders and other members accurate finishing of ends is of importance to facilitate erection on site. A new milling machine has been developed by William Asquith, Ltd., Halifax, for this particular class of work. One of these new girder end facing machines, which has been installed at the works of Dawnays, Ltd., is illustrated on this page. It is milling the end of a large stanchion with a standard "Prolite" cutter having hexagonal carbide inserts.

The spindle slide is mounted on the ways of a box-section column carried on a transverse bed, an arrangement which gives a vertical traverse of 6ft and a horizontal traverse of 10ft. In the spindle slide the milling spindle is carried in a barrel which is adjustable over a length of 3in to set the depth of cut with reference to a micrometer dial. The barrel is locked firmly for the milling operation after adjustment for cutter depth. A 20 h.p. motor on the spindle slide drives the spindle through steel-cored vee ropes, and alternative pulleys can be fitted to give spindle speeds of 870, 760 and 655 r.p.m.

The spindle slide is counterbalanced by weights hanging inside the column and its vertical traverse drive is through a two-speed motor, vee ropes and a worm and wheel. Alternative feed rates of 30in and 60in per minute or 40in and 80in per minute are available for the vertical spindle slide traverse. Horizontal traverse of the column along the bed of the machine is by a two-speed motor drive at the rear of the column.

A small self-contained motorised oiling unit is fitted for the automatic lubrication of the column base, and telescopic metal covers over the traverse bed ways keep swarf clear of the ways and the horizontal feed screw. All push button controls for the operation of the machine are arranged in a pendant which can be swung round to any position convenient to the operator.



Facing machine milling the end of a large stanchion

A demonstration of the problems presented to the body-builder by the conventional combination of a two-dimensional chassis and semi-elliptic springs

Glass Reinforced Lifeboat

TESTS have been carried out recently, at the Amsterdam Shipyard, Ltd., G. De Vries Lentsch, Jr., of a sixty persons capacity glass reinforced polyester motor lifeboat. The boat has a length overall of 28ft 2in by 9ft 2in beam by 4ft deep, and is powered by a water-cooled Coventry Victor diesel engine of 11 h.p. at 2000 r.p.m., driving through a 2 to 1 reverse reduction gear. The vertical sides of the longitudinal seats have been specially shaped to provide additional stability in the event of the boat being flooded. Hull weight is 750 kg and the food and water tanks are incorporated in the thwarts. The Authorities of the Dutch Shipping Inspection supervised the tests, which included bending tests with the boat fully loaded and also with 25 and 50 per cent overload. Changes in length and beam and the deflection were within the acceptable limits. In the second test designed to prove the efficiency of the connection of the suspension hooks to the boat, the fully loaded boat was lowered to about 6ft 8in above the water and the brakes suddenly applied to the lowering mechanism. The suspension hooks and attachments successfully withstood the shock, but the rope broke and the boat dropped into the water. Examination showed that no damage was occasioned so that the normal dropping test with a lighter load was dispensed with. The lifeboat also successfully passed the impact test in which the boat, fully loaded, was allowed to swing against the quay wall, and received the approval of the authorities.

Industrial and Labour Notes

Shipbuilding Wages

On Tuesday, the Shipbuilding Employers Federation replied to the wage claim submitted by the Confederation of Shipbuilding and Engineering Unions on behalf of workers in the shipbuilding and ship repairing industries. The claim was for a "substantial increase." The offer made by the Shipbuilding Employers Federation, 5s. 6d. a week for skilled men, 5s. for semi-skilled men and 4s. 6d. for the unskilled men, was similar to that made a fortnight ago to workers in the engineering industry. The shipbuilding employers explained that their proposals were influenced by recent wage settlements in other industries. But the offer, like that for the engineering workers, was rejected by the union confederation.

In submitting its reply to the unions, the Shipbuilding Employers Federation pointed out some of the present difficulties confronting the shipbuilding industry. The president of the Federation said that in the first seven months of this year orders for twenty-three ships totalling 283,000 gross tons had been cancelled and in the same period orders for only 144,000 tons had been secured. Unless further orders could be obtained some of the yards within the next few months would be faced with the unpleasant necessity of paying off men. Any additional increase in costs would be disastrous, the president continued, and would be a disservice not only to the country and the industry but also to the workpeople who were dependent on the industry for their livelihood.

Coal and Oil

The National Coal Board's annual summer school is being held at Oxford this week, the subject for study being "Coal and the Consumer." The opening address, last Saturday, was given by Sir James Bowman, chairman of the Board.

In particular, Sir James spoke about the Coal Board's marketing problems, and directed attention to the fact that, over a very wide range of markets, sustained and increasing competition from oil was being met. He said that oil had made great advances in those markets where it was in competition with coal, and between 1953 and 1957 its use increased to the extent of 7,500,000 tons of coal equivalent. What was more significant, Sir James continued, was the rate at which that growth was accelerating even in the face of the overall decline in industrial activity at home. The inland consumption of coal had decreased this year by 3,500,000 tons compared with the corresponding period of 1957 and by nearly 7,000,000 tons compared with 1956, but the consumption of oil had increased by 5,000,000 tons (57 per cent) and 4,250,000 tons (43 per cent) respectively.

Sir James went on to recall that only a few years ago the coal industry was unable to meet the demands of the home market, with the result that many millions of tons were imported from overseas. At that time, he said, the Government advised the Central Electricity Authority to enter into agreements with the oil companies for the development of oil-fired power stations. The programme which was subsequently drawn up provided for the consumption of oil equivalent to 9,000,000 tons of coal by 1965. This had since been reduced to 6,000,000 tons as a result of the greater availability of coal, but the latest published figures showed that, in the first six months of this year, power stations consumed oil equivalent to about 1,500,000 tons of coal. Furthermore, Sir James commented, surplus oil production capacity had brought about an even more intense competitive element within the oil industry itself. The tremendous progress of oil in the home market, he added, had been strengthened this year by price reductions in February and in April. Indeed, over the last few years the trend in the price of fuel oil compared with the price of coal had been such that in some fields it tended to become a more and more formidable competitor. Such facts as these, Sir James remarked, indicated the seriousness of the situation which the British coal industry had to face.

Employment and Unemployment

The Ministry of Labour has stated that the number of people in civil employment in Great Britain increased during July by 5000 to a total of 23,088,000. The increase was a seasonal one, for in a number of industries and services there was a drop in the number of people at work.

In the manufacturing industries, for example, the total number employed at the end of July was 9,099,000 which was 20,000 fewer than a month earlier. In this group the biggest drop was in "engineering, metal goods and precision instruments," the labour force of which fell by 11,000 to a total of 2,774,000 compared with 2,814,000 at the end of July, 1957. Employment in the vehicle industry declined during July by 6000 to a total of 1,235,000 which, however, was 9000 above the figure at the comparable date last year. In building and contracting the employment figure fell by 5000 to a total of 1,493,000. The Ministry's report notes that, in the four weeks ended August 6, the employment exchanges filled 130,000 vacancies. The number of vacancies notified but remaining unfilled on that date was 203,000 which was 11,000 less than a month earlier.

It is estimated that the number of people registered as unemployed on August 11, at 445,603, represented 2 per cent of the total number of employees, compared with 1·9 per cent on July 14. Of the August unemployment total, 402,633, were described as wholly unemployed and 42,970 temporarily stopped. The Ministry's report also notes that the number of operatives working short time in the week ended July 26 was 156,000 which was 31,000 less than in June.

Young People at Work

The National Institute of Industrial Psychology has published in its Journal, *Occupational Psychology*, a statistical survey concerned with the employment prospects of young people over the next few years. It points out that, as a result of the increase in the birthrate during the latter part of the second world war and in the immediate post-war years, the number of fifteen-year-olds in the population will increase by 1962 to 52 per cent above the 1956 figure. By 1965 the number will have fallen to 20 per cent above the 1956 figure and will remain at that level until 1971, "beyond which it is not possible to predict with any certainty."

According to the survey, it seems unlikely that these children of the "bulge" will face unemployment. If increasing industrial or other activities should prove insufficient to absorb the extra numbers who will become available, it is probable that the brunt of this will be borne by other sections of the working population, such as married women, older workers and the disabled. The main difficulties so far as young people are concerned will arise from the fact that the substantial increase in numbers will occur at what is the traditional training age. The main problem posed by the "bulge" will thus be one not of employment but of training.

The survey suggests that there are three points which should be kept particularly in mind. First, that the country's investment in education is well worthwhile. The demand for people with higher educational qualifications is likely to go on increasing and those who acquire such qualifications will profit both themselves and the country as well. Secondly, it is asserted that specialisation in too narrow a field will reduce an individual's capacity to meet the requirements of technological and other changes. It is true, the survey comments, that there has been an increasing specialisation in some fields recently which is likely to continue into the future. Personnel management is mentioned as an example, but, the survey goes on, if the need for personnel managers were to disappear to-morrow, the personnel manager would be able to make use of his experience in other fields. Thirdly, it is emphasised that boys and girls leaving school should have the benefit of the best possible vocational advice before leaving school. The work of the Youth Employment Service will thus become, it is claimed, of increasing importance. The pattern of employment in 1981, the survey says, will be vitally affected by the quality of the advice given to school leavers to-day.

Industry's Capital Expenditure

The Board of Trade estimates, from returns which it has recently received, that manufacturing industry's fixed capital expenditure is likely to be about the same this year as it was in 1957 and that, on present plans, it may be somewhat lower in 1959. The estimates indicate a fall of about 2 per cent in expenditure this year, compared with last year, with expenditure on plant, machinery and vehicles and on building work down in much the same proportion. The Board says that this must be compared with previous estimates, based on forecasts made by companies at the turn of the year, of an increase of 2 per cent, made up of a small increase in expenditure on plant, machinery and vehicles, and a small decrease in expenditure on building work. It is pointed out, however, that the uncertainties attaching to forecasts of expenditure are such that too much significance should not be attached to the relatively small change in the estimates obtained from the two sets of forecasts. The calculations made from companies' forecasts of expenditure during 1959 indicate a fall in total expenditure of about one-sixth compared with 1958, with plant, machinery and vehicles down by about a tenth and building work down by about a quarter. But these estimates are based on companies' provisional forecasts of their expenditure over a period up to nearly a year and a half ahead, many of which will be subject to re-examination later this year. They are, therefore, the Board of Trade says, subject to a greater measure of uncertainty than the estimates for 1958.

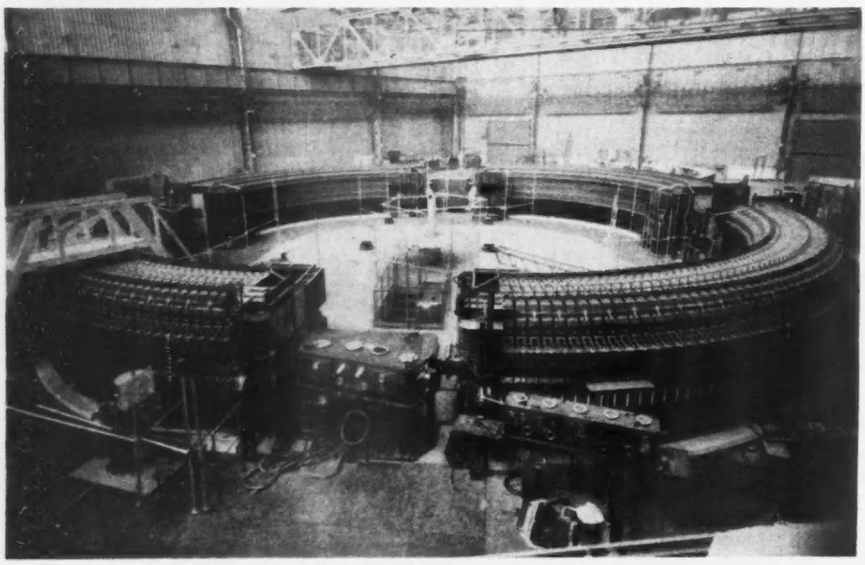
"Saturne" Proton Synchrotron

IT has been announced by the Commissariat à l'Energie Atomique that the proton synchrotron "Saturne" at the Saclay research centre was put into operation for the first time on August 12. This powerful machine which we show in the accompanying illustrations is capable of accelerating protons to energies of 2·5 GeV (2500 million electron volts). Such energies are required for the production of heavy mesons and hyperons, but are not sufficient for producing anti-protons.

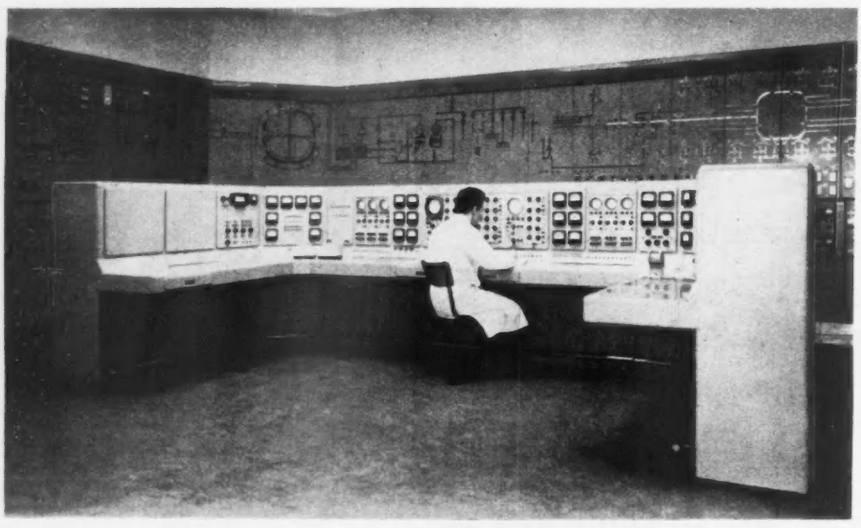
The machine comprises a ring-shaped vacuum chamber into which protons from a linear accelerator are fired at high speed. The ring comprises four 90 deg. circular bends round which the particles are made to travel by a magnetic field at right angles to the plane of the ring. During each revolution the particles pass through an acceleration space where an electric field imparts to them an additional energy of 1100 electron volts.

The ring inside which the particles move is of rectangular cross-section measuring 50cm in width and 10·5cm in height. In it a vacuum of the order of 5mm by 10^{-6}mm Hg. has to be maintained. The average diameter of the ring is approximately 17m, and the total weight of iron in the magnet core is 1100 tonnes. About 55 tonnes of copper were required for the windings.

For the time being, the machine is being operated at the rate of one pulse (one complete cycle of acceleration) every six seconds, but it is intended eventually to double this rate. Each cycle lasts about 0·8 second during which time the particles go round the ring some 2,500,000 times, traversing a total distance of 150,000km. As the speed of the particles increases on each circuit so must the frequency of the electric field in the accelerator space be speeded up. Initially, this frequency is 0·75 Mc/s, but by the end of the acceleration period it has increased to 8·5 Mc/s. Simultaneously, the magnetic field in the ring must be stepped up at a rate designed to keep the particles on a circular path of constant radius. For this purpose the magnetic intensity has to be increased from zero to over 14,000 gauss. It is announced that in the first runs of the machine, the design energy of 2·5 GeV was reached, the cycles lasting about 700 milliseconds. About 10^7 to 10^9 particles were accelerated in each cycle. It will be the aim during the next few months to improve the performance further. Construction of "Saturne" began in 1954, and occupied about thirty-five engineers and physicists. Together with laboratories and auxiliary installations the equipment cost approximately 6000 million francs to build.



Magnet ring of proton synchrotron "Saturne" during construction. The four right-angle bend sections of the magnet contain approximately 1100 tonnes of steel and 55 tonnes of copper



Control room of "Saturne" proton synchrotron. The left part of the mimic panel shows the magnet ring circuits; on the right, diagram of the accelerating system

Provisional International Computation Centre

The Provisional International Computation Centre was established by a bi-lateral agreement concluded in September, 1957, between Unesco and the Italian Institute of Higher Mathematics (Instituto Nazionale di Alta Matematica) pending the establishment of an International Computation Centre on a permanent basis. The Centre has been created for a period of two years but will automatically cease to exist when the intergovernmental Convention establishing an International Computation Centre comes into force. It commenced its activities in January, 1958, and is located in a modern building on the outskirts of Rome, in the Zona dell'Esposizione Universale a Roma.

The main function will be to ensure mutual assistance and international collaboration beween existing bodies dealing with computation and information processing, in particular as regards scientific and technological studies. The Centre will promote the exchange of information both on scientific matters and on the facilities existing in various countries. It will also help, on request, those countries which do not possess their own computation equipment. This assistance may consist either of undertaking certain computation tasks with the help of existing services or of giving advice for the creation of national centres. The same help will also be available to international organisations. The Centre will promote the training of specialised staff, and will also endeavour to be a link between the users and the designers of computation equipment.

The activities of the Centre are being carried out under the guidance of the Preparatory Committee of the International Computation Centre, which is composed of a representative of Unesco, a representative of the Italian Institute of Higher Mathematics and a representative of each country which agrees to pay a financial contribution to the Centre.

The Preparatory Committee met on December 16–17, 1957, at Unesco House, Paris, in order to nominate its Executive Secretary and to adopt directives concerning the programme of the Centre. A number of suggestions were made as to topics for research. These included partial differential equations, linear algebraic equations, eigenvalue problems, programmation and problems concerning the standardisation of machine languages.

Organisations and experts are invited to draw the attention of the Centre to specific problems for which they feel that an international exchange of views would be useful. The Centre will then consider the organisation of small working groups or symposia on well-defined subjects, with the participation of experts particularly qualified to contribute to the progress of such studies.

With regard to training, the general view was that the Centre should not itself organise training courses, as such courses are now being held or planned by a number of competent organisations in various countries. It could, however, play a useful role by circulating news to all interested persons and organisations about training courses which are being planned in various countries; advising and helping in the organisation of such courses; circulating news about available fellowships; contributing towards the creation of additional fellowships; helping in the recruitment of the most suitable candidates; and assisting candidates in planning their programme of study abroad. On the basis of present estimates the Centre will be able to spend about 10,000 dollars on fellowships during the two years 1958–59. In addition, it is expected that a number of fellowships will be made available for the period 1959–60 by the General Conference of Unesco, which will meet in November 1958.

One of the first tasks is to collect information on existing services and to make this information available to all interested persons and bodies. For this purpose, it is planned to publish an index which will be composed of loose sheets so that it may be continually kept up to date.

High-Temperature Research at the National Bureau of Standards

BY OUR AMERICAN EDITOR

No. II—(*Continued from page* 393, *August 5th*)

Recent developments in high-speed flight, rocket propulsion, and nuclear reactors have raised operational temperatures from well below 1000 *deg. Cent. into a range up to* 4000 *deg. Cent., in which there had been little scientific or industrial experience. Until recently the work on materials done by the National Bureau of Standards was largely confined to the more conventional temperature ranges. However, a high-temperature research programme has grown quickly, mainly as a result of the Bureau's efforts to meet its assigned responsibility for devising precise measurement methods and determination of the basic properties of materials. The high-temperature research programme may be divided into three groups :* (1) *Studies of structure ;* (2) *determination of properties and constants of materials ; and* (3) *development of methods and instrumentation for high-temperature measurements.*

Corrosion by Liquid and Gaseous Metals

DURING an investigation to determine the cause of failure in riveted galvanised steel ship plates, it was found that the rivet heads frequently popped off at relatively low riveting temperatures. This was believed to have been caused by penetration of either liquid or gaseous zinc into steel stressed in tension. The Bureau is now studying the mechanism by which solid metals are attacked by a second metal of lower melting temperature in both liquid and gaseous phases. Plans are to extend the study to higher-temperature fields and to determine the basic mechanism of such corrosive attack, including the effect of crystal orientation of the solid metal, the solid-liquid or solid-gas interface reactions, and the nature of penetration of either metallic or gaseous phases.

Time-Lapse Photography

A time-lapse photographic technique for measuring the rate at which a solid surface is attacked by corrosive gases at high temperatures has recently been developed by the Bureau in a project supported by the U.S. Atomic Energy Commission. The photographs provide a permanent record of the reactions and permit accurate measurement of the rate of change of mass of the solid from its changes in dimension. The method is rapid and simple and can be applied to a considerable variety of gas-solid reactions. Because of the severe experimental complications that arise at high temperatures, few reaction rate studies of gas-solid reactions involving volatile products have been made even though such studies would give valuable information on the mechanism of corrosion. The manner in which the time-lapse photographic method solves many of the high-temperature problems can be seen, for example, in its application to the very rapid reaction between nickel and chlorine.

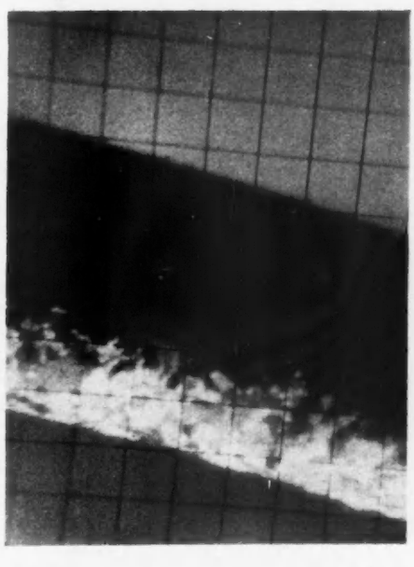


Fig. 7—Time-lapse photograph of nickel wire during a corrosive attack by chlorine gas

Working at temperatures from 1100 deg. to 1700 deg. Kelvin, a group studied the reaction in which nickel and chlorine form gaseous nickel chloride. The nickel was in the form of a cylindrical wire through which a current was passed to provide the desired temperatures (Fig. 7). The reaction took place in a " Pyrex " vessel which could be evacuated to pressures as low as 10^{-6}mm of mercury ; during the experiments chlorine was flowed through the vessel at various constant pressures between 0·1mm and 0·5mm of mercury. The vessel has two windows in side arms at right angles to each other. Through one of the windows an optical pyrometer is directed towards the nickel sample to observe its temperature. Through the other the time-lapse photographs are taken. Illumination is by radiation from the sample, and a lens system produces an image of the sample, on film, eight times actual size. A microswitch operated by a synchronous motor releases the shutter and advances the film at regular intervals. From a series of ten or fifteen exposures taken at intervals of fifteen or thirty seconds, it was established that the rate of change of sample diameter and, therefore, the rate of reaction, is constant with time for the periods observed (Fig. 8). An analysis of the data showed that the reaction rate is proportional to the chlorine pressure and extremely rapid—at least one out of every five chlorine molecule collisions with the nickel surface leads to a reaction.

Viscosity Measurements

As part of the Bureau's programme to develop techniques and instruments for measuring properties of materials at high temperatures, the glass laboratory is developing an " oscillating-cup " viscometer to measure the viscosity of liquid inorganic oxides at temperatures up to 2000 deg. Cent. or higher. The feasibility of the method for measurements in the anticipated viscosity range using convenient cup dimensions has been demonstrated with a prototype model. Values of the viscosity of a liquid and its rate of change with temperature find immediate application in fundamental research on molecular structure. Viscosity data are also of direct use in many technological problems—for example, in calculating the forces required for the mechanical transport of a liquid. However, before such data can be obtained for temperatures above 1500 deg. Cent., the array of problems that confront nearly all high-temperature measurements must be effectively met. Among the more serious difficulties are those of corrosion and vaporisation at high temperatures. Both of these factors produce changes not only in the mass and geometry of the sample, but possibly in its composition as well ; and stray vapours can react harmfully with critical parts of the apparatus. Also, for greater dimensional stability and reproducibility, it is desirable that the instrument be simple in shape and construction.

In the case of viscosity measurement, there is an additional specific requirement. At sufficiently high temperatures the viscosity becomes so small that it can no longer be measured by the techniques in common use for liquids. The instrumentation must therefore be suitable for measuring low liquid viscosities well below the order of 1 centipose for the inorganic oxides.

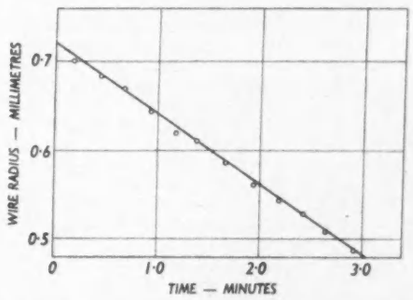


Fig. 8—Graph showing the decrease in diameter on nickel wire due to attack by chlorine gas

The oscillating-cup method appears to be adaptable to the requirements mentioned. The principle of operation is simple (Fig. 9). The sample liquid is enclosed in a cup which is suspended from a wire to form a torsion pendulum ; when torsional vibrations are started, the presence of the liquid causes them to be damped. As the amount of damping depends on the viscosity, the latter can be calculated from the observed rate at which the vibrations decay. The mathematical problem of deriving the viscosity from the rate of decay is rather complex, but an adequate approximate solution is available using a high-speed computer. Decay of amplitude of vibration is exponential with time and only a few oscillations need to be observed to establish the decay rate. This increases the range of viscosities which can be measured in the relatively short times over which the high temperatures are easily maintainable. However, the method is primarily applicable for relatively low viscosities ; higher viscosities would require inconvenient cup dimensions.

A prototype of an oscillating-cup apparatus has been constructed to investigate this method of measurement as applied to liquids (Fig. 10).

Measurements were made on oils having known viscosities in the range of interest and were carried out at room temperature and up to

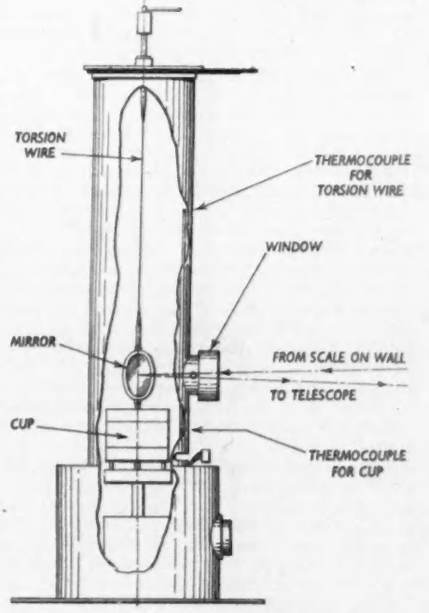


Fig. 9—Cut-away drawing of high-temperature viscometer measuring torsional oscillation of the cup

several hundred degrees Centigrade. The results show that the technique is satisfactory as a means of measuring low liquid viscosities. Parallel studies have also been made with a view to selecting materials and modifying the design to adapt it to use at high temperatures, and the design of a high-temperature model is now well advanced.

Studies of the corrosive effect of boron trioxide on molybdenum, tungsten and tantalum at temperatures up to 2100 deg. Cent. have been made for the N.B.S. glass laboratory by the Wright Air Development Centre. These studies show that of these metals molybdenum offers the most resistance to corrosion, with the other two following in the order named. Initial plans call for a cup constructed of molybdenum plus 0·5 per cent titanium to counteract embrittlement encountered with pure molybdenum at high temperatures. The cup will be protected from oxidation by operating it in a vacuum or in an inert atmosphere such as nitrogen or argon made slightly reducing by the addition of a few per cent of hydrogen. It is expected that this material will prove satisfactory for temperatures as high as a few hundred degrees above 2000 deg. Cent. For measurements at still higher temperatures it will probably be necessary to use other materials, possibly new types of ceramics now under development.

In addition to the work on the oscillating-cup viscometer, it is planned to explore the possibility of determining viscosity at high temperature from measurements on the damping of ultrasonic oscillations of a small probe immersed in the experimental liquid. An attempt will first be made to modify commercially available probes to high-temperature use. The glass laboratory is also planning a survey of general techniques and specific designs for the measurement of surface tension at high temperatures, with the aim of selecting one or more for intensive development effort.

High-Temperature Transformations

In the high-temperature research programme of the National Bureau of Standards, attention is given not only to the measurement of properties of materials at elevated temperatures, but also to the way in which materials are transformed and their properties change as the temperature rises. Current interest centres on the rates at which various properties change, temperature ranges in which special phenomena occur, sudden transitions that take place at fixed temperatures, and changes induced by combining high temperature with high pressure. The usefulness of a material for high-temperature applications is largely determined by the nature and extent of such changes.

Inversion studies are of particular interest because they contribute to knowledge of the volume stability of materials in various temperature ranges. At the Bureau such studies have been made on refractory oxides, including the technologically important substance, silicon dioxide. This compound has several forms, including quartz and cristobalite. Quartz is a low-temperature form, while cristobalite can exist in two modifications that are stable at low and high temperatures respectively. The temperature at which inversion from high- to low-temperature cristobalite occurs has been reported at different values from 180 deg. to 270 deg. Cent. In the past this variation has been attributed to heat treatment—the higher the temperature of preparation, the higher the inversion temperature. This inversion has been reinvestigated by the Bureau, using specially purified material. The results show that inversion occurs at a fixed temperature (271 deg. Cent.) provided that the cristobalite has been prepared at a sufficiently high temperature (above 1400 deg. Cent.) to effect proper crystal perfection.

Several other refractory oxides that show solid-phase inversion have also been studied. One of the more interesting is zirconium oxide. At low temperatures the crystallographic form of zirconium oxide is monoclinic, but above 1000 deg. Cent. it inverts to a tetragonal form which is stable up to the melting point. However, the addition of a small amount of calcium oxide to the zirconium oxide stabilises another (cubic) form; this form persists from melting point down to room temperature without inversion, and therefore without the undesirable volume change that accompanies inversion. Zirconium oxide is thus converted to a useful, volume-stable refractory.

Plastic deformation and ultimate strength are among the physical properties of solids that depend strongly on the presence of lattice defects and impurities. The Bureau is investigating such processes in metallic oxides; among these, aluminium oxide was chosen for concentrated study because it is one of the strongest of the refractory materials and is available both as large single crystals and in polycrystalline form.

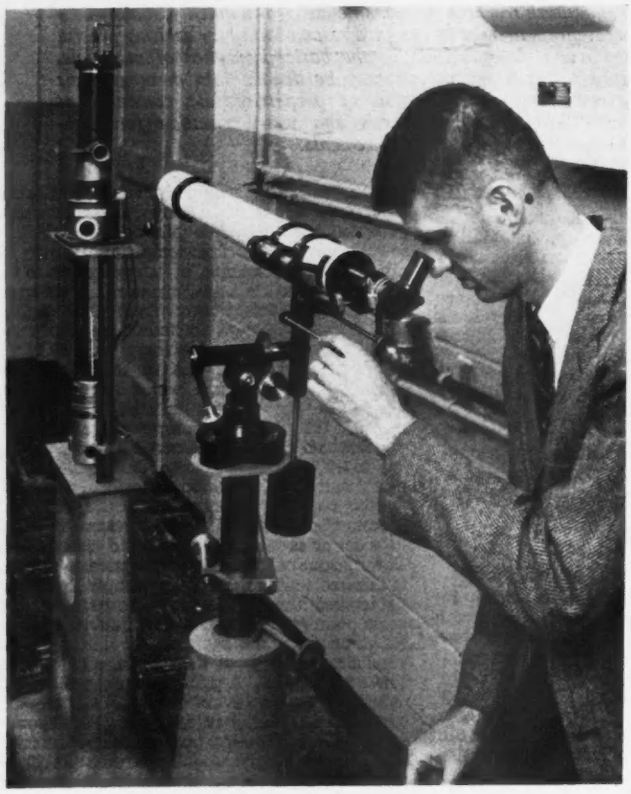


Fig. 10—Prototype of N.B.S. high-temperature viscometer for measuring viscosity of liquid inorganic oxides at temperatures up to 2000 deg. Cent.

It was found that single-crystal aluminium oxide begins to exhibit creep at 900 deg. Cent.; at 1000 deg. Cent. some of the crystals could be stretched by 2 per cent. This extension always results from the same type of motion relative to the crystal structure; i.e. by slip along the hexagonal base plane in the direction of an "a" axis; so that plasticity at 1000 deg. Cent. is an extremely anisotropic property. For extension to occur, the tensile stress must be applied obliquely to the base plane; if the stress is either parallel or perpendicular to the base plane no creep appears until the temperature is increased to 1600 deg. Cent., when some other, unidentified, mode of deformation becomes active. However, at 1500 deg. Cent. a crystal subject to a tensile stress at 45 deg. to the hexagonal base plane can be extended to more than twice its original length.

The deformation occurring in these crystals has two characteristic features. First, it requires an incubation period at 1000 deg. Cent. for as long as 70 hours under stress before measurable creep occurs. If the specimen is then held at the same temperature and under constant stress, there is, first, a period of increasing creep rate, after which the rate decreases, approaching a constant value. At higher temperatures the incubation period is shorter or absent altogether, and a final period of accelerated creep, associated with "necking" of the crystal, may occur. Secondly, at a given temperature, a certain value of stress—the creep yield stress—must be exceeded to initiate measurable creep; this value of the stress is strongly temperature-dependent. At 1400 deg. Cent. a tensile stress of 250 kg per square centimetre is sufficient to initiate creep; at 900 deg. Cent., 1560 kg per square centimetre is required; and at lower temperatures the specimens always failed in a brittle manner without measurable plastic deformation. Further experiments showed that once creep had started at 1000 deg. Cent., it would continue at a stress considerably below the creep yield stress. The presence of impurities can raise the stress required to start creep; at 1200 deg. Cent. specimens with less than 1 per cent chromium oxide had a creep yield stress about twice as large as that for pure aluminium oxide. These results call for interpretation in terms of the stress necessary to move dislocations in the aluminium oxide structure.

Polycrystalline aluminium oxide behaved in a completely brittle manner at room temperature. However, at 1000 deg. Cent. it exhibited a type of plastic deformation quite different from that found in single crystals. Small amounts of creep took place at stresses well below the creep yield stress for single crystals; the creep began immediately on application of load and the creep rate steadily decreased thereafter. When the load was removed after ten hours, as much as half the total deformation was recovered by creep in the opposite direction in the following ten hours. The mechanism of this creep and subsequent recovery is thought to be grain boundary slip. Creep in aluminium oxide and in other refractory metal oxides (Fig. 11) which have been studied in less detail, depends on two defects—dislocations and grain boundaries—and on their interaction with impurities. Dynamic measurement of elastic moduli and internal friction provide a sensitive means for studying defects and impurities; a method has been developed for making such measurements at temperatures above 1000 deg. Cent. Experiments are now under way to study the effects of grain boundary viscosity and dislocation motion on the temperature, frequency and time-dependence of Young's modulus and the internal friction.

Advanced research on rockets and nuclear power plants has emphasised the inadequacy of present knowledge regarding vaporisation or sublimation processes at high temperatures. The lack of knowledge results in part from the view, held not too long ago, that the vapour phase plays no important part in the high-temperature processing or technological application of solids. However, a growing body of evidence suggests that while sublimation processes may not in general be rate-determining, they often have a major influence on reactions at high temperatures. In line with the changed outlook, it is no longer common to assume that metals vaporise as monomers, or that ionic compounds retain in the vapour phase the valency relations characteristic of the solid phase. High-temperature chemical studies have in many cases revealed a complete reversal of low-temperature behaviour; so that the experimenter is faced with the possible

Fig. 11—Measurement of elongation of sapphire crystal in study of creep at high temperature, using an optical extensiometer

existence of a large number of molecular species quite beyond his usual experience.

Four main aspects of high-temperature vapour phenomena are of current interest. These may be termed the kinetic, microscopic, thermodynamic and chemical aspects, and are concerned, respectively, with : (1) the quantity of material that vaporises from unit area in unit time, or the rate of linear regression of a surface in a vacuum or in contact with various gases ; (2) the mechanism by which individual atoms or ions acquire sufficient energy to leave the surface ; (3) the energies associated with phase changes and reactions, and (4) identification of the vaporising species and the reactions occurring at the interface between solid or liquid and gas phases. Recently the Bureau has been measuring the loss in weight at high temperature of single and polycrystalline specimens of known surface area. Changes in weight are measured with a Gulbransen microbalance (Fig. 12) designed for loads up to 4 grammes and with a sensitivity of 1 microgramme. Specimens are suspended from the balance and, if they are electrically conducting, are heated by direct induction. If non-conducting, they are suspended in an inductively heated furnace ; i.e. the specimen is held near a " susceptor," or material capable of being heated inductively. As an example of the results obtained thus far, it has been possible to show that water vapour has no measurable effect on the rate of evaporation of alumina up to 1600 deg. Cent., but that at the melting point (2050 deg. Cent.) it considerably enhances the rate of evaporation. Furthermore, by increasing the partial pressure of oxygen in the surrounding region, the rate of evaporation can be retarded.

It is well known that greater pressure favours the formation of compounds with higher density ; so that, for example, the pressures existing far below the earth's surface are largely responsible for the formation of gems and other high-density substances with unusual properties. An investigation now under way aims to imitate this natural process and, by a simultaneous application of high temperature and high pressure, to synthesise crystals of high purity and to measure precisely their properties. Thus, a form of talc has been produced in which part of the water is replaced by fluorine ; this new form has proved stable, i.e. it persists after the pressure and temperature are returned to normal. Similar experiments with water and with lime, on the other hand, generated crystalline forms that continued only as long as the extreme conditions were maintained. Also, the plastic, polytetrafluoroethylene, was found to take several new but temporary forms. In another experiment, the gem, beryl ($3BeO.Al_2O_3.6SiO_2$) was synthesised and its stability limits, as well as those of natural beryl, were determined.

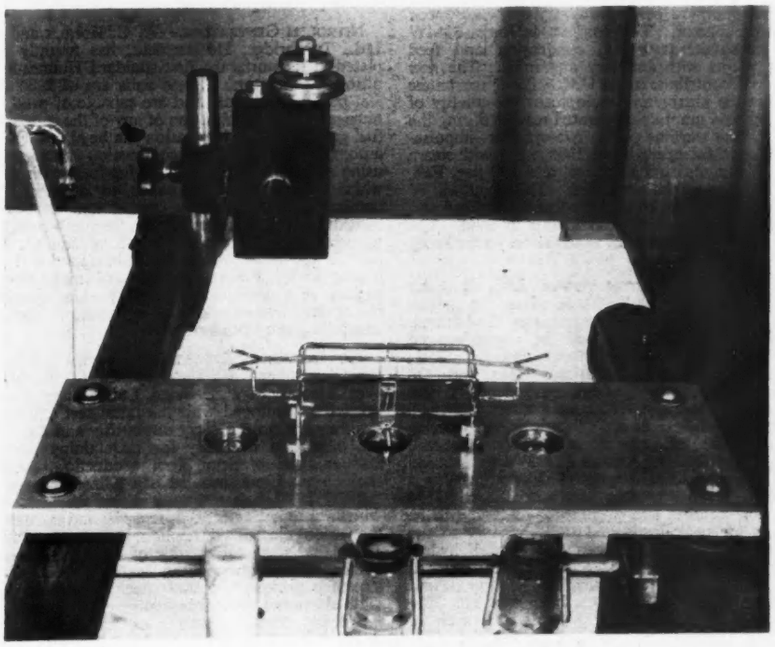


Fig. 12—N.B.S. microbalance for study of vaporisation and sublimation at high temperatures

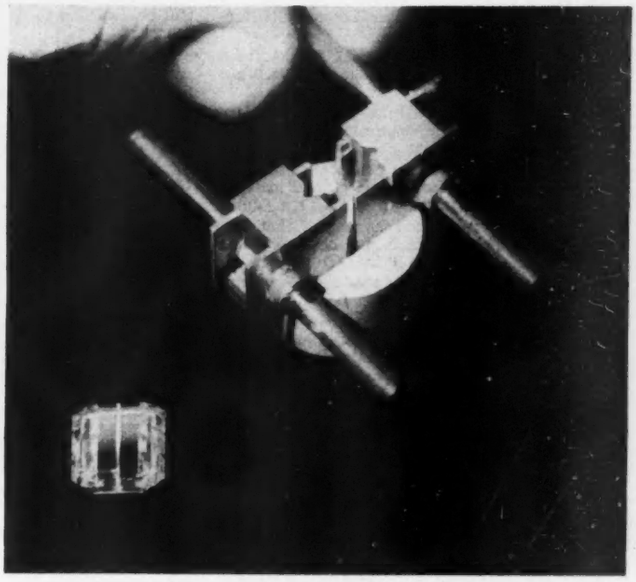


Fig. 13—Diamond used as high-pressure cell (left), steel pistons (right) and mounting jig for the diamond (centre)

An unusual piece of apparatus (Fig. 13) used in this work is a 7·5 carat diamond confiscated from a smuggler by the U.S. Bureau of Customs and turned over to the National Bureau of Standards by the General Services Administration. The diamond is a flawless specimen of the rare type II that is transparent to infra-red radiation up to wavelengths of 20 microns. This has the advantage that, when the diamond is used as a pressure cell, it is possible to obtain the infra-red transmission spectrum of the material being studied ; this, in turn, yields important information about changes taking place in the arrangement of the atoms within the material. The original emerald-cut diamond was modified into a pressure cell by drilling a hole 0·015in in diameter through its centre. Two pistons of hard tool steel that closely fit the hole are inserted, one from each end, with the sample under study between them. Because of the small cross-section of the cell, a force of only 80 lb is required to bring the internal pressure to 450,000 lb per square inch, the maximum that can be attained without danger of splitting the diamond.

(To be concluded)

Personal and Business

Appointments

MR. D. L. PHILLIPS has joined Mills and Rockleys (Production), Ltd., to control the printed circuit division.

MR. PETER LIDDELL has been appointed general manager of the Dunlop Rubber Company (Indonesia), Ltd.

MR. J. H. H. GILLESPIE, A.M.I.C.E., has been appointed assistant chief engineer to the Tyne Improvement Commission.

MR. J. T. SHARPLES, A.M.I.Mech.E., has joined the British Electrical Development Association as industrial heating engineer.

Mr. W. ERIC WARD, works production manager, has been appointed a director and general manager of Consett Iron Company, Ltd.

BIRFIELD INDUSTRIES, Ltd., announces that Mr. G. W. Kelland, A.M.I.Mech.E., has been appointed public relations officer of the Birfield Group.

THE MINISTRY OF TRANSPORT AND CIVIL AVIATION has appointed Sir Leonard Sinclair to be a part-time member of the British Transport Commission.

THE TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY, Ltd., announces that Mr. H. F. Wilson has been appointed managing director of the Telcon Cables Group.

SCOTTISH LAND DEVELOPMENT CORPORATION announces that Mr. Kenneth H. Osborne has been appointed managing director, and Mr. Niall D. Hodge, chairman.

THE MINISTRY OF POWER has announced that Mr. F. C. Lant has been appointed chief fuel engineer in succession to Rear Admiral Sir Sydney O. Frew, K.B.E., who has retired from the public service.

DR. R. V. HUGHES has been appointed to the research centre of Ruston and Hornsby, Ltd., and is now responsible for the general administration and technical development programme for the complete range of diesel engines.

MR. C. E. ROEBUCK has been appointed chief estimating engineer of the newly-created engineering estimating department at Steel, Peech and Tozer, a branch of the United Steel Companies, Ltd. Mr. D. E. Barker succeeds Mr. Roebuck as chief planning engineer.

FIRTH-VICKERS STAINLESS STEELS, Ltd., has announced that Mr. J. T. W. Dewar, joint managing director, has been appointed managing director, following the retirement of Mr. C. E. Holmstrom, joint managing director. Mr. Holmstrom has been appointed a non-executive director.

REMINGTON RAND, Ltd., announces that Mr. G. McLean, the company's secretary and a director, has relinquished his position to take up a post with the American parent organisation, the Sperry Rand Corporation. Mr. J. S. Chalmers, chief accountant, has been appointed secretary and controller of the company.

THE BRITISH BROADCASTING CORPORATION has announced the appointment of Mr. D. Hinchliffe, A.M.I.E.E., as engineer-in-charge, Holme Moss television and v.h.f. sound transmitting station, in succession to Mr. C. Buckle, A.M.I.E.E., who recently became engineer-in-charge at the Droitwich transmitting station.

A.C.V. SALES, Ltd., announces the following appointments: Mr. J. D. Slater has been appointed to the board and will combine the duties of director and commercial manager; Mr. L. C. Parsons has been appointed secretary of Park Royal Vehicles, Ltd., and Mr. J. Ford has assumed responsibility for the secretaryship of A.C.V. Sales, Ltd.

EDGAR ALLEN AND CO., Ltd., has announced the following appointments in its engineering department: Mr. J. Higginbotham, deputy general manager; Mr. J. D. Studholme, assistant general manager; Mr. A. Brunton, commercial manager; Mr. A. Wallis, chief draughtsman (production); Mr. J. D. Lee, chief draughtsman (development), and Mr. S. Carter, chief estimator.

Business Announcements

VICTOR PRODUCTS (WALLSEND) Ltd., states that its London address is now 1327, London Road, Norbury, S.W.16 (telephone Pollards 0077–8).

THE BRITISH TRANSPORT COMMISSION has announced that Mr. C. R. Atkins, stores superintendent, Scottish Region, British Railways, retired on August 31.

ELCONTROL, Ltd., states that its London sales office, sales and service staff have been transferred to Wilbury Way, Hitchin, Herts (telephone Hitchin 2411).

DR. ESMOND WASSELL SMITH has relinquished his executive duties with the Telegraph Construction and Maintenance Company, Ltd., after forty-eight years' service.

MR. W. H. GLASS, a director of Thermotank, Ltd., for twenty-five years, has retired, but his services will still be available to the company in a consultative capacity.

B. AND K. LABORATORIES, Ltd., states that it is now installed in its new headquarters at 4, Tilney Street, Park Lane, London, W.1 (telephone Grosvenor 4567).

BRITISH INSULATED CALLENDER'S CABLES, Ltd., is to open a new depot at Oakcroft Road, Chessington, Surrey, on Monday, September 15 (telephone Lower Hook 2323).

GEORGE COHEN, SONS AND CO., Ltd., states that sales in the United Kingdom of "Pingon" tower cranes will in future be handled by its contractors' plant department.

MR. LEONARD CLARKE, M.I.Mech.E., is to retire from the position of managing director of L. Clarke and Co., Ltd., on September 30. He will remain on the board of directors.

CHARLES CHURCHILL AND CO., Ltd., has announced the retirement of Mr. David Nicholson, who since 1946 has been sales manager, engineer supplies division, at the Birmingham headquarters.

CAMP BIRD, Ltd., states that arrangements have been made to merge the manufacturing and trading operations of H. J. Baldwin and Co., Ltd., Duratube and Wire, Ltd., and Hartley Electromotives, Ltd.

THE TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY, Ltd., has announced that Dr. E. W. Smith has relinquished his executive duties on reaching the age of 65, after forty-eight years' service with the company.

MR. J. C. MITCHELL, M.I.Mech.E., M.I.E.E., controller of the north-eastern division of the Central Electricity Generating Board is to retire on September 30 after more than forty years in the electricity supply industry.

Contracts

E.M.I. ELECTRONICS, Ltd. has received orders worth more than 1,000,000 dollars for an advanced design of airborne radar equipment for use in aircraft of the Royal Canadian Air Force. This radar equipment is the latest E.M.I. aid to submarine detection. It is being fitted in the Canadair "Argus" aircraft —a Canadian manufactured military version of the "Britannia"—designed for long-range anti-submarine and reconnaissance work. It can also be used as a navigational aid.

THE ENGLISH ELECTRIC COMPANY, Ltd. has received an order for turbine plant for the United Kingdom Atomic Energy Authority's new advanced gas-cooled reactor. The contract is for a 33MW steam turbo-alternator set, condensing and feed heating plants with auxiliary apparatus. The new reactor will contribute to the U.K.A.E.A. programme to realise the maximum development potentiality of the gas-cooled graphite-moderated reactor during the 1960s. The turbine is a two-cylinder impulse-reaction machine operating at 3000 r.p.m. with steam at 650 lb per square inch gauge, and 850 deg. Fah. The alternator will be air-cooled. This plant will be manufactured at the company's Rugby, Stafford and Netherton works for commissioning in 1961. The unit is a well-tried design of which seventy are already in service.

NATIONAL FREE PISTON POWER, Ltd., is under contract to supply £500,000 of plant for a free-piston gas turbine power installation in Finland. The free-piston gasifiers will be manufactured (under licence from Alan Muntz and Co., Ltd., Pescara and SEP) by National Gas and Oil Engine Company, Ltd., of Ashton-under-Lyne and the gas expansion turbines and alternators will be made by the Brush Electrical Engineering Company, Ltd., of Loughborough. The plant will form an extension to the existing 6MW steam station at Riihimaki, and will consist of two 6MW gas expansion turbo-alternator sets and sixteen GS34 free-piston gasifiers and ancillary plant. It will be operated for peak loads and stand-by duty to the base load plant to supplement the Finnish hydro-electric grid supplying power to the industrial and rural area around the towns of Riihimaki and Hyvinkaa, about 100 miles north of Helsinki. The equipment will be supplied in two stages, each of one gas expansion turbo-alternator set and eight free-piston gasifiers; the first stage is planned to be commissioned by winter 1960.

Miscellanea

IMPROVED EFFICIENCIES OF FLUORESCENT LAMPS.—Progressive introduction of "Mazda" fluorescent lamps with improved efficiencies of from 10 to 15 per cent, resulting from improvements in manufacturing methods, is announced by the A.E.I. Lamp and Lighting Company, Ltd., 18, Bedford Square, London, W.C.1. For example, the light output of the 80W 5ft fluorescent "Daylight" lamp is stated to have been increased from 4080 to 4480 lumens (average) through the first 5000 hours.

ECONOMIC TYPE BOILERS.—A series of articles entitled "Economic-type Boiler Defects and Repairs," by Mr. Sydney D. Scorer, which appeared in *The Steam Engineer*, has now been reprinted in book form. The sections of the book deal with design and manufacturing conditions; furnaces; end and tube plates; combustion chambers; stays and stayed surfaces; tubes; and automatic controls. The book concludes with a series of useful furnace tables for the easy calculation of safe working pressure. Copies of the publication are available at 7s. 6d. from John D. Troop, Ltd., 90, High Holborn, London, W.C.1.

UNDERGROUND VEHICLE DOCKS.—The extension of Selfridges' store in Oxford Street, London, has commenced with the putting into use of an underground receiving depot, which has allowed the selling area on the ground floor to be extended. The underground vehicle area totals 21,000 square feet, and the spacing of the columns supporting the store (including the car park under construction on the first floor) is 33ft by 35ft. Vehicles over 16ft high can enter down a 1 in 10 ramp with electric heating elements embedded in the surface concrete for de-icing. The exit ramp has a maximum gradient of 1 in 8. The area drains into a 8000-gallon sump emptied by pumps, and is positively ventilated to extract petrol and exhaust fumes. Goods lifts from the docks serve all floors, and another will be installed to carry semi-trailers full of furniture to the floor on which the goods are needed.

EXHIBITIONS OF NICKEL ALLOYS.—A series of four-day exhibitions devoted to the practical uses of nickel and its alloys are to be held by Henry Wiggin and Co., Ltd., the first at the Royal Station Hotel, Newcastle upon Tyne from September 23 to 26; the second at the Metropole Hotel, Leeds, from October 14 to 17, and the final one from October 28 to 31 at the Grand Central Hotel, Belfast. Running concurrently with each exhibition will be a series of lectures and film shows demonstrating the practical uses of Wiggin alloys in high-temperature work, and in chemical and electrical engineering, and others will feature welding techniques. The exhibition will include comprehensive displays illustrating the various properties of the alloys—corrosion resistance, high-temperature properties, electrical resistance and special physical properties.

NITROGEN GENERATORS.—W. C. Holmes and Co., Ltd., Turnbridge, Huddersfield, has recently completed at its works the first standard Holmes-Kemp nitrogen generators. These units are of 2000 cubic feet per hour capacity and are capable of producing nitrogen by the combustion of any of the commercial fuel gases with air. Operation can be almost entirely automatic and controlled combustion is achieved by using a carburettor, giving varying fuel to air ratios, which automatically responds to demand. The combustion products are cooled and the carbon dioxide is removed by passing the gas through an adsorber tower containing mono-ethanolamine. Each unit is complete with reboiler, stripper and heat exchanger for the regeneration of mono-ethanolamine. A compressor can be provided for storing the gas under pressure and a dryer is also available to ensure freedom from moisture.

HOB INSPECTION DEPARTMENT.—A new hob inspection department has been opened at the Manor Works factory of W. E. Sykes, Ltd., Staines, Middlesex. It is equipped with the latest test equipment, enabling the firm to carry out swiftly and accurately the inspection necessary for maintaining the high standards of precision tool production. Among the new machines installed is a Klingelnberg model "PWF 250" hob testing machine which is fitted with an automatic electronic recorder and can measure the various elements of the hob, including cumulative errors that were not capable of direct measurement before. Other equipment in the department includes a profile projector, a lead checking machine (also with electronic recording equipment), thread pitch measuring machine, hob flank angle tester, flute division checker, bore checker, floating carriage micrometer, Vickers hardness tester and a hob flute radiality checker.

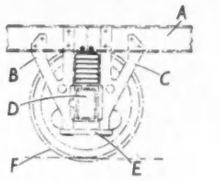
British Patent Specifications

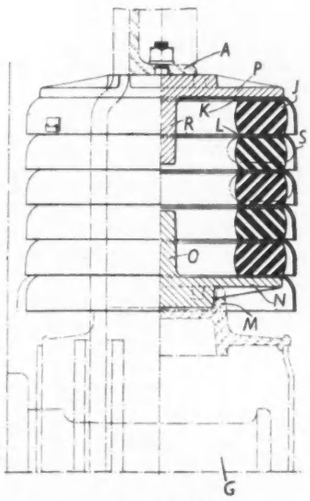
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

RAILWAY ENGINEERING

799,144. May 17, 1955.—AXLEBOX MOUNTING FOR RAILWAY ROLLING STOCK, George Spencer, Moulton and Co., Ltd., 13 and 14, Ashley Place, Westminster, London, S.W.1. (*Inventor: Alexander Eric Moulton.*)

The invention relates to railway rolling stock and the mounting of axleboxes, particularly in goods wagons. Referring to the drawing, in the upper view *A* represents a portion of the frame of a wagon, *B* and *C* are horn plates between which is an axlebox *D*, and *E* is a retaining bar across the soles of the horn plates. *F* is a flanged road wheel riding a rail and *G* its axle. A rubber compression spring unit comprising five oval rubber rings *J*, each bonded between upper and lower plates *K* and *L*, is interposed between the axlebox and the wagon frame, the former being provided with a suitable seat flanged at *M* and on which seat





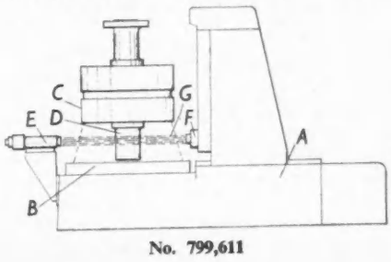
No. 799,144

rests a plate *N* having a central spigot *O* locating the lowermost elements of the column. A similar plate *P* with a depending spigot *R* is carried by the wagon frame, and the spigots serve a secondary function as limit stops regulating the extent to which the frame may approach the axlebox under overload conditions. Integral protecting skirts *S* are formed on the lower plates of each element serving also to axially align the five elements making up the column.—*August* 6, 1958.

MACHINE TOOLS

799,611. February 9, 1956.—GEAR HOBBING MACHINES, Craven Brothers (Manchester), Ltd., Vauxhall Works, Reddish, Stockport, and Alfred Kurt Thomas, of the company's address.

The invention relates to gear hobbing, grinding or shaving machines, and has for its object to provide improved means for setting up a gear blank with its axis concentric with the axis of rotation of the work table, especially on a large gear hobbing machine.



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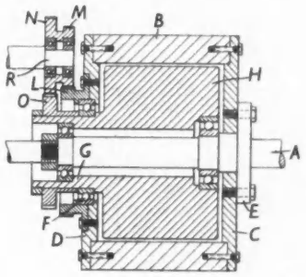
In the drawing there is shown, in outline, a hobbing machine *A* comprising a rotatable work table *B* on which it is desired to position a turbine reduction gear blank *C* with its lower journal *D* concentric with the axis of rotation of the table. In accordance with the invention, a telescope *E* and light source *F* are mounted on the machine so that the light beam *G* passes tangentially along the journal *D*, the necessary support (shown in broken lines) for a blank being interrupted at certain intervals to allow the beam to pass. The telescope *E* is provided with a measuring scale to enable any variation in concentricity of the journal to be read by directly observing through the telescope the position of the edge of the shadow cast by the journal in relation to the scale. If the journal does not run true with the axis of rotation of the table *B* the shadow on the measuring scale will move according to the extent of eccentricity. To accommodate differing sizes of journals the telescope and/or the lamp are adjustably mounted on the machine.—*August* 13, 1958.

POWER TRANSMISSION

799,341. April 13, 1956.—FLYWHEEL ARRANGEMENTS, Stone-Chance, Ltd., Gatwick Road, Crawley, Sussex. (*Inventor: Clement Elphick Gossling.*)

The invention concerns improvements relating to flywheel arrangements, in which rotating masses are used for energy storage. With such arrangements, the problem not infrequently arises of obtaining a sufficient flywheel mass within a given space whilst limiting the peripheral speed to a reliably safe value, a speed of 250ft per second being not usually exceeded in the case of steel flywheels. The invention seeks to increase the kinetic energy which can safely be made available with a given mass. In the drawing, a driving shaft *A*, connected to a source of power, is directly coupled to an annular flywheel *B* by end plates *C* and *D*. One end plate *C* is connected to



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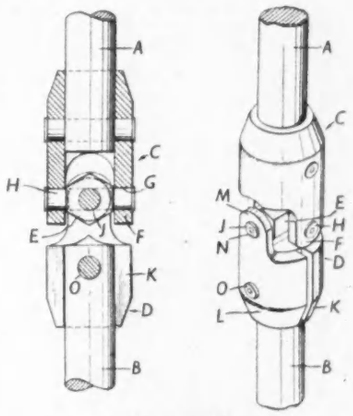
a flange *E* on the shaft *A* and the other end plate *D* is mounted by a ball bearing *F* on a hub-like extension *G* of a second, inner, flywheel *H*, which is, in turn, mounted on the shaft by roller bearings. The inner flywheel *H* is driven through step-up gearing, which may be of a positive or frictional nature, so that it rotates at a higher speed than the outer wheel. As illustrated, a toothed wheel *L* fixed on the end plate *D* may drive a pinion *M* fast with a larger pinion *N* driving a wheel *O* fixed, concentrically with the shaft, on the extension *G* from the inner flywheel *H*. The pair of pinions *M* and *N* is mounted on a stub or pivot *R* suitably supported from the frame of a machine with which the arrangement is employed. The outer flywheel *B* is rotated with a conservative peripheral speed giving the usual high factor of safety over the ultimate strength of the material. Through the gearing the inner flywheel is caused to run at a much higher speed, and under greater stress, so that its mass is utilised more economically. If the inner flywheel should fail, no serious damage would be caused, as parts would be restrained by the annular flywheel, and its end plates which form a cage. In practice, provision may be made for introducing torsional flexibility in the drive between the two flywheels in order to avoid unnecessary oscillations. If necessary, damping means, which may be of either a fluid or frictional nature, may also be provided.—*August* 6, 1958.

800,194. January 26, 1956.—UNIVERSAL JOINTS, Coach Fittings Development, Ltd., 10, Marsh Street, Walsall, Staffordshire. (*Inventor: Wilfrid Overton.*)

According to the invention, in a universal joint of the Hooke's type, the spider has one pair of trunnions formed integrally on it, the co-operating fork or yoke member being longitudinally divided before assembly, whilst the other pair of trunnions is formed by a single cylindrical pin passing through a bore in the spider, and the co-operating fork or yoke member is of one-piece construction. The joint illustrated in the drawing is between two shafts *A* and *B* which may be required to rotate with their axes inclined to one another. The joint comprises the usual fork or yoke members *C* and *D* mounted on the ends of the shafts, and a centre member or spider *E* pivotally connected to both yokes. The upper yoke *C* connected to the shaft *A* is of the conventional kind, comprising a hollow substantially cylindrical body, a close fit over the shaft, and having at one end a pair of lugs *F* at diametrically opposite points, provided with bearing eyes *G* for receiving a pivot pin *H*, by which the yoke is pivotally connected to the



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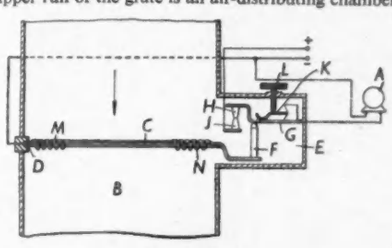
spider *E*. The spider has integral axially aligned trunnions *J* projecting from opposite ends, which connect it to the other yoke *D*. The yoke *D* is similar in shape to the upper yoke *C*, but is longitudinally divided into two parts *K* and *L*, each including a limb *M* having a bearing eye *N* for receiving rotatably a trunnion *J*. Each of the parts *K* and *L* is thus a substantially semi-cylindrical member formed at one end with a substantially semi-cylindrical inner surface of radius substantially equal to that of the shaft *B* upon which it is to be mounted and at the other end with a limb *M*. The parts *K* and *L* are assembled on the end of the shaft *B* with their bearing eyes *N* receiving the trunnions *J*, and are secured in position by a pin *O* passed through transverse eyes and a bore in the shaft *B*, the ends of the pin *O* being riveted over. The ends of the trunnions *J* are also riveted over where they project from the eyes. With this construction, the centre member or spider *E* requires only one separate pivot pin *H*, and this is a solid pin, the usual divided pivot pins not being required. The joint is thus simple to manufacture and is stronger when assembled. The spider *E* preferably has flat bearing surfaces surrounding the trunnions *J* and the ends of the bore through which the pin *H* is passed, these surfaces being perpendicular to the trunnions and the bore for engagement by the inner faces of the limbs *M*.—*August* 20, 1958.

MECHANICAL STOKERS

799,591. March 29, 1956.—SOLID-FUEL COMBUSTION APPLIANCES, C.U.R.A. Patents, Ltd., Randalls Road, Leatherhead, Surrey. (*Inventor: Alex David Chalmers Gunn.*)

The invention relates to solid-fuel combustion appliances in which the fuel undergoes combustion in the form of a bed which is charged by a mechanical stoker. As shown in the drawing the appliance comprises a chain grate of the usual form which is driven by an electric motor *A* and on to which fuel is fed from a hopper at the forward end of the grate, the depth of the fuel bed on the grate being controlled by a movable guillotine. Situated beneath the upper run of the grate is an air-distributing chamber,



No. 799,591

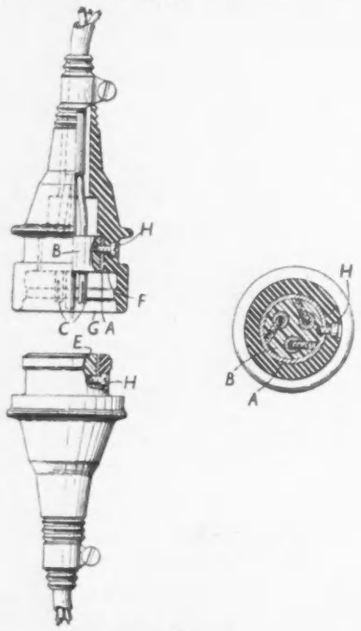
and a conduit *B* for the supply of combustion air to the appliance communicates with the interior of the chamber near to the forward end. Mounted transversely within the conduit *B* is a bimetallic strip *C* of which one end is secured at *D* to one wall of the conduit *B* and of which the other end is free to move in a recess *E* in the opposite wall of the conduit. The free end of the strip carries a plunger *F* which bears against an arm *G* carrying a contact *H*, being one of a pair of switch contacts *H* and *J*, the other contact *J* being rigidly connected to one wall of the

recess *E*. A spring *K* bears against the arm *G* and tends to maintain the switch formed by the contacts in the closed position. The force exerted by the spring may be varied by an adjusting screw *L*. Two heating coils *M* and *N*, which are connected in series with one another, are wound round the bimetallic strip *C*, one at each end, and the arrangement is such that, when the strip is heated, the plunger *F* tends to urge the arm *G* against the action of the spring *K* to open the switch *H* and *J*. The switch is connected in series with the heating coils *M* and *N*, and also with the electric motor *A*. When the switch is closed, the motor is in operation and current flows through the heating coils *M* and *N*. The current through the heating coils is selected so that, except when the rate of supply of air is a maximum, the rate of supply of heat to the bimetallic strip *C* is always greater (when the heating coils are in operation) than the rate of loss of heat from the bimetallic strip to the air flowing through the conduit *B* (as indicated by the arrow) over the bimetallic strip *C*. Thus, unless the rate of flow of air is the maximum, the temperature of the strip rises at a rate which depends upon the rate of flow of air until it reaches a value at which the plunger *F* attached to the free end of the strip moves the arm *G* to open the switch *H* and *J*. The motor then stops and current ceases to flow through the heating coils *M* and *N*. The bimetallic strip then cools at a rate which depends upon the rate of flow of air over the strip. When the temperature of the bimetallic strip falls to the value at which the plunger *F* moves to allow the arm *G* to move under the action of the spring to close the switch *H* and *J*, the motor restarts and a current again flows through the heating coils. When the rate of supply of air is the maximum, the motor runs continuously, but when the rate is decreased, the motor runs intermittently, the fraction of the time for which the motor is running increasing when the rate of supply of air increases and decreasing when said rate decreases. It has been found that, for rates of flow of air up to 25ft per second, changes in the rate of supply of fuel are approximately proportional to changes in the rate of supply of air. The rate of change of the fuel supply rate with respect to the air supply rate is less than one, i.e. the rate of supply of fuel increases more slowly than the rate of supply of air, and this rate of change decreases as the current through the heating coils *M* and *N* is increased.—*August* 13, 1958.

ELECTRICAL ENGINEERING

800,037. April 28, 1955.—CABLE COUPLINGS OF PLUG AND SOCKET TYPE, Simmonds and Stokes (Niphan), Ltd., Victoria House, Southampton Row, London, W.C.1. (*Inventor: William Charles James.*)

The invention relates to electrical cable couplings of plug and socket type in which one at least of the casings is made of moulded rubber. The main object of the invention is to provide a rubber-clad coupling in which a secure mode of holding an insulator block is employed. As the drawing shows,



No. 800,037

in this arrangement a liner *A* is inserted in the recess which accommodates an insulator block *B*. In the case of the plug part of the coupling, as shown in the upper view, the block *B* is provided with contact pins *C*. The corresponding block *E* in the socket part, see the lower view, is provided with pin-receiving socket holes. The liner *A* has a length equal to the depth of the recess so that it finishes flush with the floor *F* of a counterbore constituted, in the case of the plug part of the coupling, by the skirt *G* which protects the pins and embraces the end of the socket-carrying casing when the parts are coupled together. One or more fixing screws *H* are set into the side of the casing so as to pass through an opening in the liner *A* into a blind hole in the side of the block.—*August* 20, 1958.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

ENGINEERING DRAWING PRACTICE

No. 308A—Students' edition. Price 4s. 6d. (less one-third discount to students).—A specially abridged, low-priced version of this Standard has now been issued and will be welcomed by technical students —and doubtless by their tutors also. B.S. 308A (inclusion of the suffix is important when ordering copies) is intended for students who are in the early stages of an engineering education. This forty-page publication contains much of the "solid meat" of the complete edition of B.S. 308. Each page of the abridged version carries a cross-reference to the equivalent page of the parent edition. The parts of B.S. 308 excluded from this abridgment are those dealing with drawing-office procedure, the layout of industrial drawings, and geometrical tolerancing—all subjects not generally taught until a higher stage of study is reached. "It is important, however, to introduce the idea of geometrical tolerancing and its problems at the earliest possible stage of the course," the standard points out.

CABLES AND FLEXIBLE CORDS FOR ELECTRICAL EQUIPMENT OF SHIPS

No. 883 : 1958. Price 15s. This revision aligns the standard with B.S. 7 : 1953, B.S. 480 : 1954, and B.S. 608 : 1956, for rubber-insulated, paper-insulated and varnished-cambric-insulated cables, respectively, as far as the special conditions of shipboard use permit. One additional type of cable, polychloroprene-sheathed without braid, has been introduced; but tough rubber-sheathed cables, apart from flexible cables and flexible cords, are no longer specified for use in ships—they have been superseded for this purpose by the more fire-resistant polychloroprene-sheathed cables. The quality of rubber insulation, rubber-like fire-resisting insulation, rubber sheath and polychloroprene sheath is defined by reference to B.S. 2899. The requirements for paper insulation and varnish-cambric-insulation are similar to those of B.S. 480 and B.S. 608, respectively. The section on mineral-insulated cables has been omitted from this edition of B.S. 883 because a new British Standard for mineral-insulated cables, which will be equally applicable to cables for use on land and in ships, is expected to be published shortly.

Catalogues and Brochures

KEITH BLACKMAN, Ltd., Mill Mead Road, Tottenham, London, N.17.—Publication No. 41 describing small "Tornado" fans and blowers.

THE UNITED KINGDOM GLYCERINE PRODUCERS' ASSOCIATION, Ltd., 5, Bridewell Place, London, E.C.4.—Booklet listing 1700 ways to use glycerine.

GENERAL REFRACTORIES, Ltd., Genefax House, Sheffield, 10.—Illustrated leaflet giving details of "Chelford" sands for the iron, steel and non-ferrous industries.

BARLOW-WHITNEY, Ltd., 2, Dorset Square, London, N.W.1.—Engineering data sheet No. ZMP-558 describing "B-W" type ZMP white metal pots for zinc, lead, tin, &c.

HENRY RIGHTON AND CO., Ltd., 70–84, Pentonville Road, London, N.1.—Comprehensive stock and weights booklet covering the range of non-ferrous metals carried in stock by the company.

W. C. HOLMES AND CO., Ltd., Gas Handling Division, P.O. Box B.7, Turnbridge, Huddersfield.—Publication No. 75 describing "Holmes-Connersville" range of "XAS" type exhausters and boosters.

THE CONSOLIDATED PNEUMATIC TOOL COMPANY, Ltd., 232, Dawes Road, London, S.W.6.—Catalogue giving details of design, application and operation of class FE horizontal, double acting balanced opposed compressors.

THE ADDISON ELECTRIC COMPANY, Ltd., 10–12, Bosworth Road, London, W.10.—Leaflet describing spark testers for detecting insulation faults in insulated wires and cables during production, or in a separate reeling operation.

BRITISH MONORAIL, Ltd., Wakefield Road, Brighouse, Yorkshire.—Illustrated catalogue giving technical details of standard "Monorail" and "Girder-Rail" overhead handling systems, designed to carry loads up to and including 2 tons.

BRITISH RESIN PRODUCTS, Ltd., Devonshire House, Piccadilly, London, W.1.—Technical information sheet No. 8 dealing with the effect of various processing techniques on the density of articles produced from "Rigidex" high density polyethylene.

THE NEW CONVEYOR COMPANY, Ltd., Brook Street, Smethwick, Birmingham, 40.—Illustrated brochure presenting the general overall developments of various types of conveyors and installations in machine shop and press shop mechanisation schemes. Details of the "Wissmann" type conveyor system are also included.

ELCONTROL, Ltd., Wilbury Way, Hitchin, Herts.—Data Sheet dealing with the operation and use of industrial flame failure and ignition programming controllers. Two different ranges are described: the "FSP" series for use with oil burners only, and the "FSM" series for use with gas burners or gas-ignited oil burners (can also be used with oil burners).

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF PUBLIC LIGHTING ENGINEERS

Tues., to Fri., Sept. 16 *to* 19.—Annual conference, Harrogate. "Lighting for Safety and Amenity."

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Tues., Sept. 16.—ALDERSHOT AND DISTRICTS BRANCH: Red Cross Hall, High Street, Aldershot, "Radio Frequency Heating," P. B. Curtis, 7.30 p.m. ★WEST KENT BRANCH: Royal Star Hotel, Maidstone, Kent, "Electricity in Horticulture," F. M. Proctor, 7.30 p.m.

Wed., Sept. 17.—LUTON BRANCH: Luton Chamber of Commerce, George Street West, Luton, "Fluorescent Lighting 415V," 8 p.m.

Thurs., Sept. 18.—WOLVERHAMPTON AND DISTRICT BRANCH: Chamber of Commerce, District Bank Chambers, Lichfield Street, Wolverhampton, "Earth Leakage Protection," J. A. Robbins, 7.45 p.m.

Fri., Sept. 19.—STOKE AND CREWE BRANCH: Grand Hotel, Hanley, "Electricity Supply and Distribution in North Staffordshire," C. C. Pimble, 7.30 p.m.

INCORPORATED PLANT ENGINEERS

Tues., Sept. 16.—BIRMINGHAM BRANCH: Hotel Leofric, Coventry, "Clean Air," R. Williams, 7.30 p.m.

Wed., Sept. 17.—KENT BRANCH: Kings Head Hotel, High Street, Rochester, "General Outline of Some of the Problems Involved in Space Travel," 7 p.m.

Thurs., Sept. 18.—BLACKBURN BRANCH: White Bull Hotel, Blackburn, "Recent Advances towards Thermonuclear Power ('Sceptre' and 'Zeta')," J. E. Read, 7.30 p.m.

Tues., Sept. 23.—SOUTH WALES BRANCH: South Wales Engineers' Institute, Park Place, Cardiff, Films on "Lubrication Methods," 7.30 p.m.

INSTITUTE OF PETROLEUM

Wed., Sept. 17.—61, New Cavendish Street, London, W.1, "Harmful Effects of Electrostatic Charges on Machinery and Lubricating Oils," T. Salomon, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Sat., Sept. 20.—NORTH-EASTERN GRADUATE AND STUDENT SECTION: Visit to Edinburgh, 8 a.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Wed., Sept. 17.—Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, Presidential Address, R. Arbuthnott, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Sat., Sept. 13.—YORKSHIRE GRADUATE SECTION: Visit to Ferryside "B" Power Station, 10 a.m.

Tues., Sept. 16.—EASTERN GRADUATE SECTION: Evening Visit to Goldington Power Station, Bedford. ★SOUTHERN GRADUATE SECTION: Visit to Vickers-Armstrongs (Aircraft), Ltd., Weybridge, Surrey, 2–5 p.m.

Wed., Sept. 17.—SOUTHERN BRANCH: Technical College, Farnborough, "World-Wide Operating Experience with 750–1000kW Gas Turbines," G. B. Feilden, 7.30 p.m.

Thurs., Sept. 18.—MIDLAND BRANCH: James Watt Memorial Institute, Great Charles Street, Birmingham, "Management Control of Small Engineering Firms," L. Fontaine, W. R. Spencer and J. W. Walker, 6 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Wed., Sept. 17.—LEEDS GRADUATE SECTION: Visit to Samuel Fox and Co., Ltd., Stocksbridge Work, Near Sheffield, 6 p.m., "Steel Production," 7.30 p.m. ★BIRMINGHAM SECTION: College of Technology, Gosta Green, Birmingham, Films, 7.30 p.m. ★WOLVERHAMPTON GRADUATE SECTION: Wolverhampton and Staffs College of Technology, Wulfruna Street, Wolverhampton, "Engineering Metrology," J. R. Adams, 7 p.m. ★EDINBURGH SECTION: North British Hotel, Princes Street, Edinburgh, Ladies Evening and Film Show, "Travel by British Transport," 7.30 p.m.

Sat., Sept. 20.—LUTON GRADUATE SECTION: Visit to the British Tabulating Machine Company, Ltd., Letchworth, 10 a.m.

PHYSICAL SOCIETY

Wed. to Sat., Sept. 17 *to* 20.—University College, Swansea, Autumn Conference on "Gas Discharges," Opening of Conference, September 17, 2.30 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Tues., Sept. 16.—CORROSION GROUP: Kings Head Hotel, Newport, Mon, Joint Meeting with the South Wales Section and with the Cardiff Section of the Royal Institute of Chemistry, "Some Factors Affecting the Performance of Condenser and Heat Exchanger Tubes," P. T. Gilbert, 7 p.m.

TELEVISION SOCIETY

Fri., Sept. 19.—Cinematograph Exhibitors' Association Theatre, Third Floor, 164, Shaftesbury Avenue, London, W.C.2, "Experimental Colour Receiver: Setting Up and Adjustment," E. Ribchester, 7 p.m.

Advanced Engineering Courses

Communication Engineering Economics. DEPARTMENT OF ELECTRICAL ENGINEERING, South East London Technical College, Lewisham Way, London, S.E.4. A course of twenty-six lectures, commencing Monday, October 6, 6.45 p.m., of particular interest to post office engineers and traffic officers and to staff of firms engaged in the preparation of tenders for the supply and installation of communication equipment for export. Application should be made to the Head of the Electrical Engineering Department. Fee £1 12s. 6d.

Electronic Computing Systems. Part I: The Construction and Operation of Electric Digital Computing Systems Designed for Commercial Purposes. DEPARTMENT OF MATHEMATICS, SIR JOHN CASS COLLEGE, Jewry Street, Aldgate, London, E.C.3.—A course of nine lectures, commencing Wednesday, October 8, 6.30 p.m., intended for executives and others interested in the commercial applications of electronic computers. Application should be made to the Secretary of the College. Fee, for those residing in the County of London, £1.

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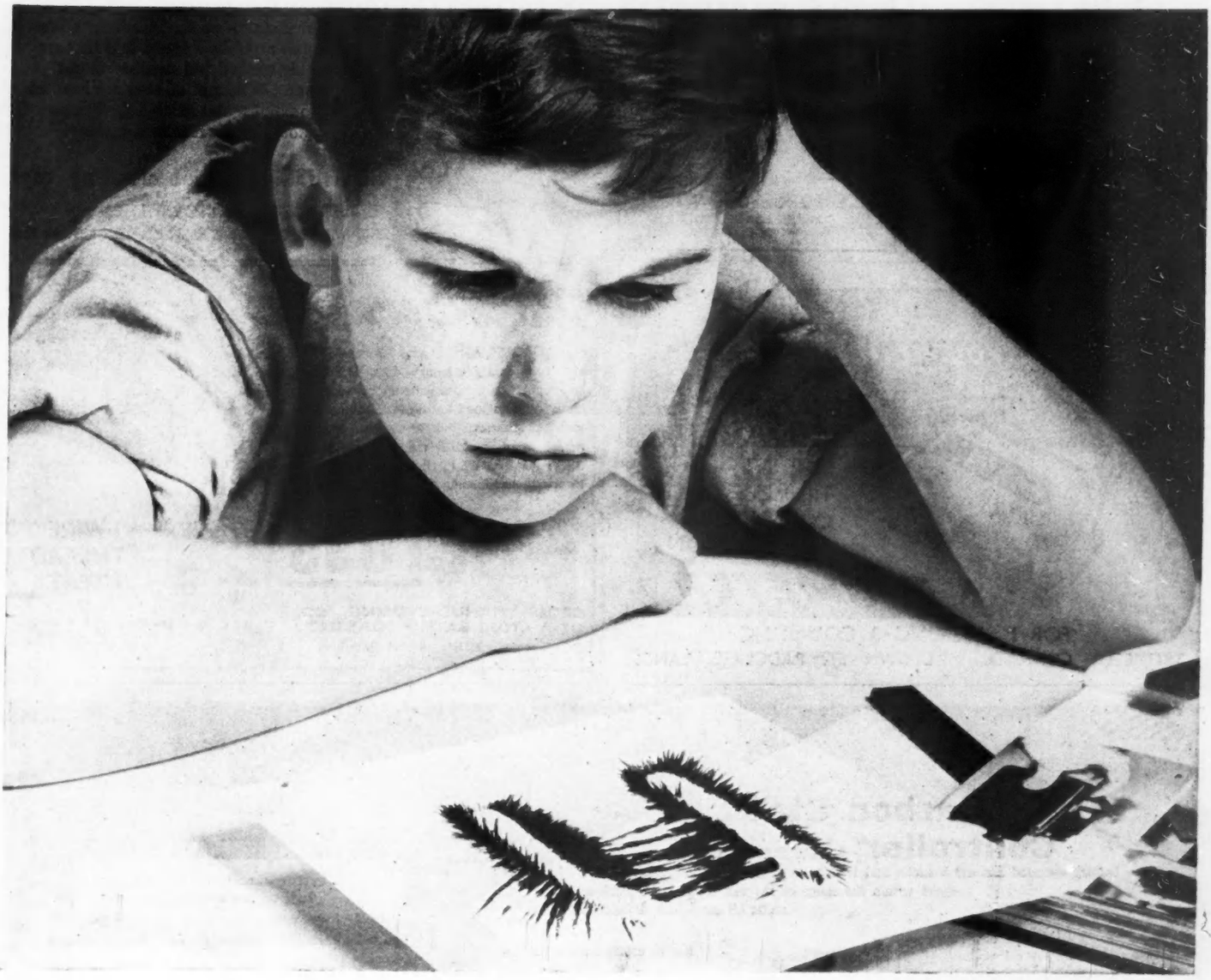

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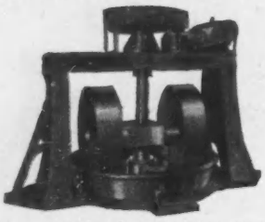

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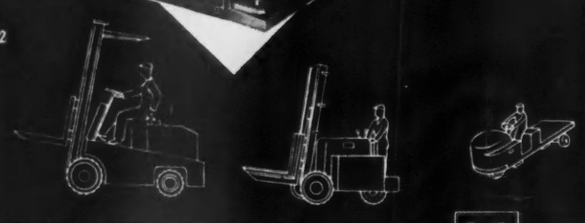

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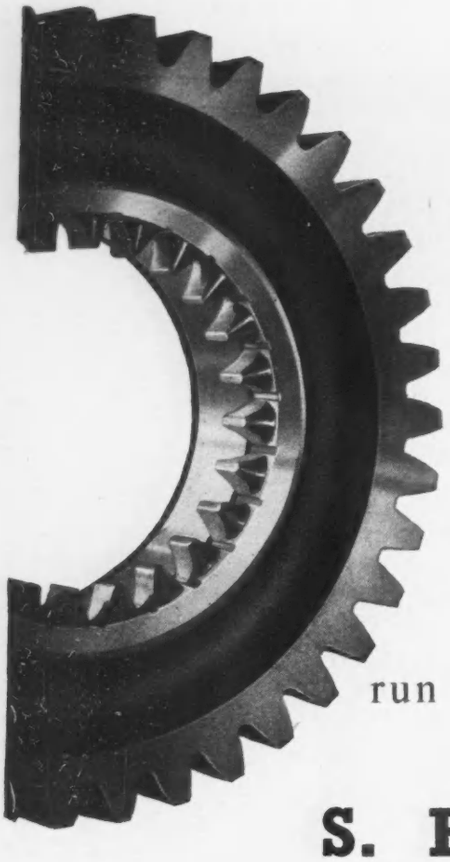

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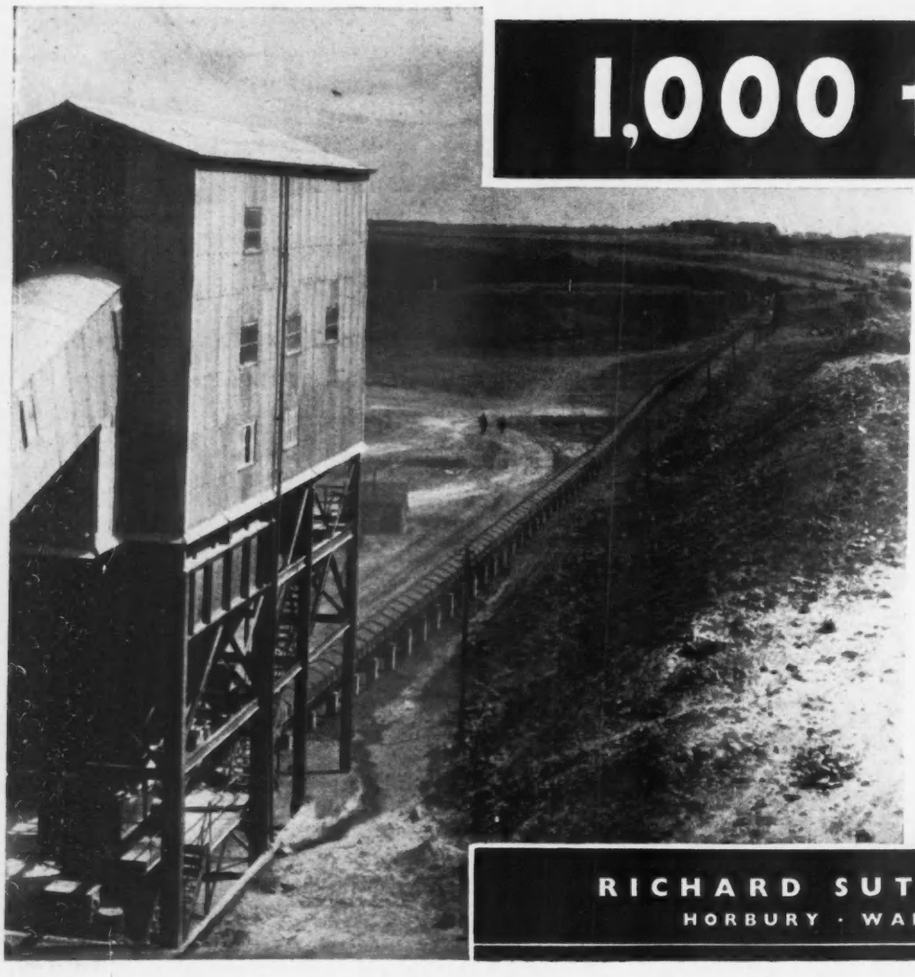

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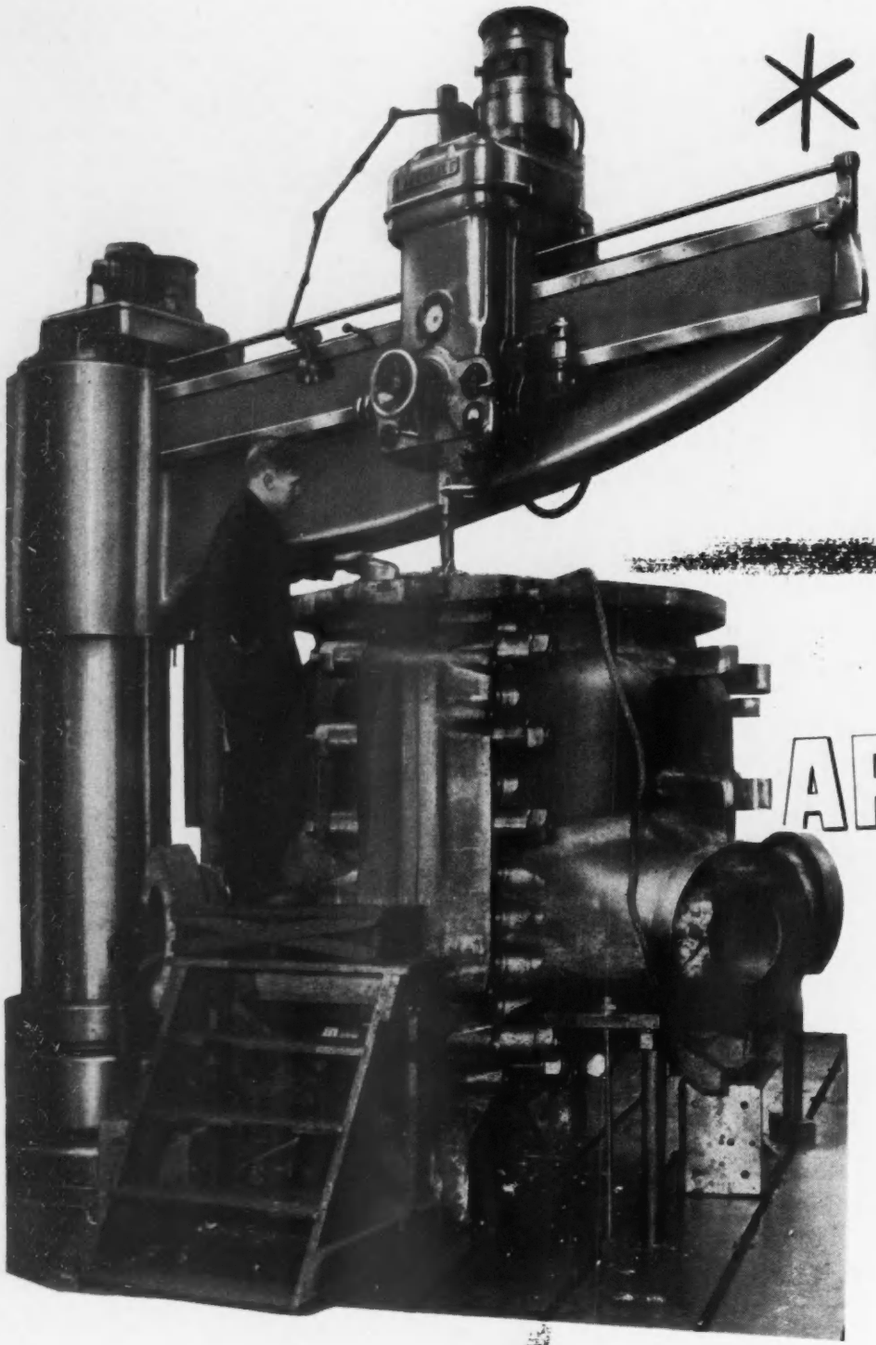

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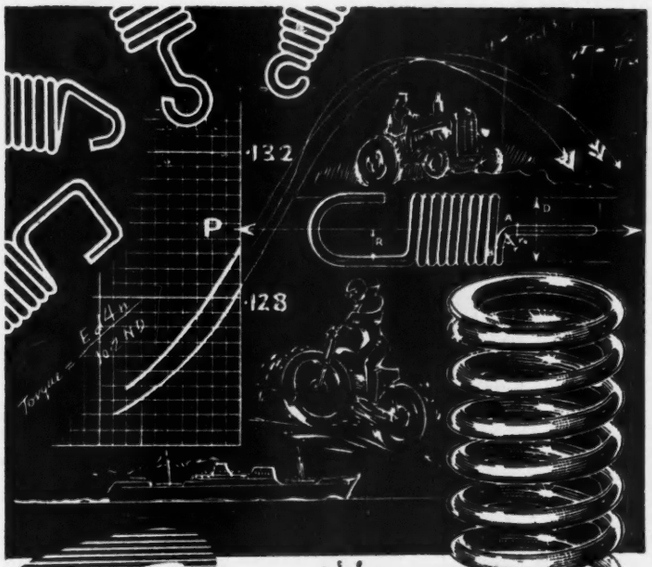

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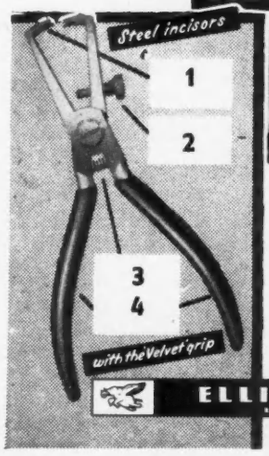

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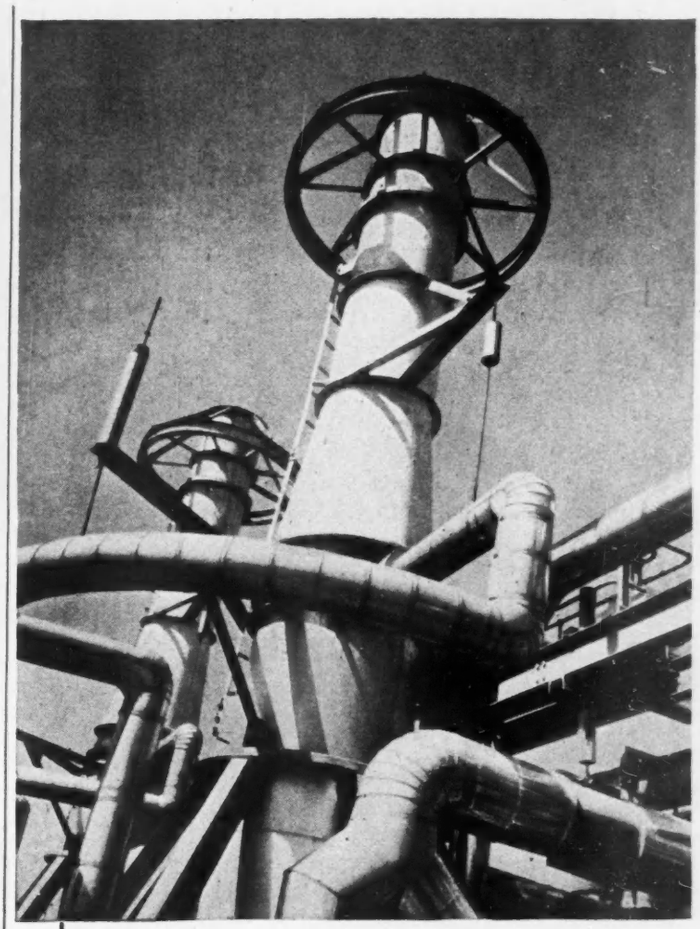

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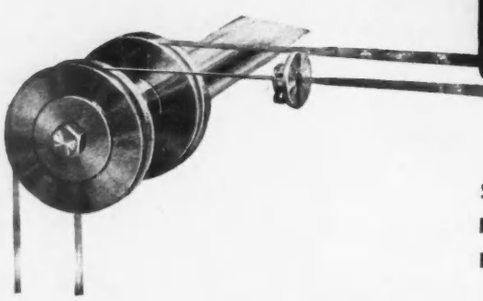

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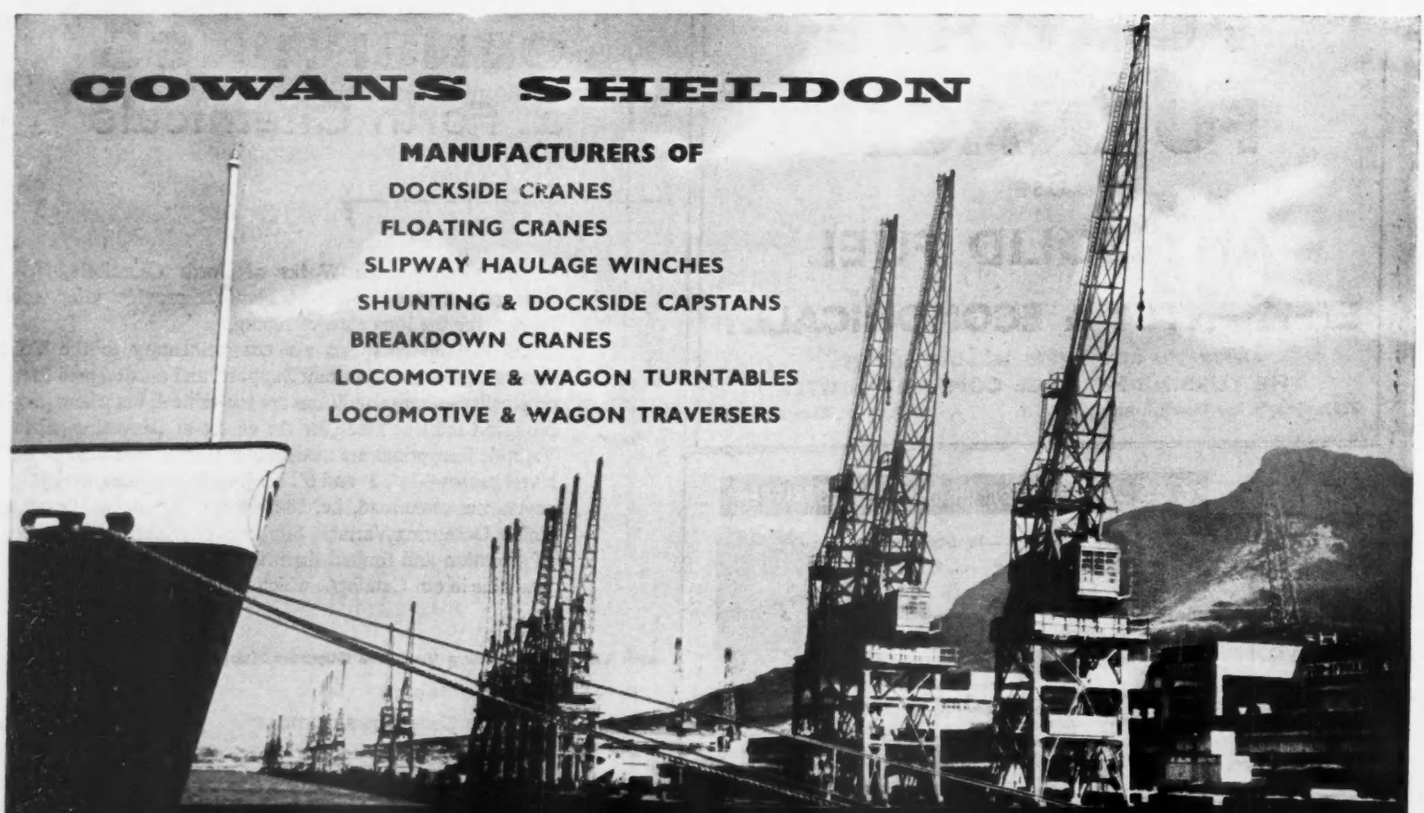

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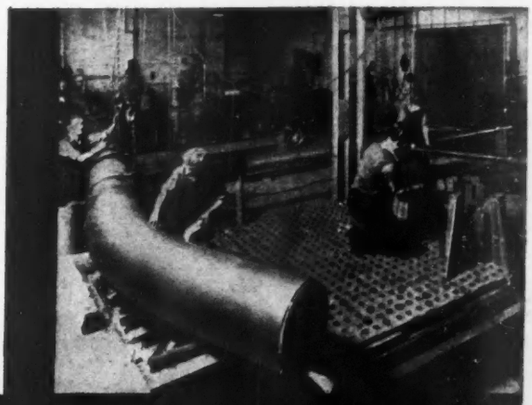
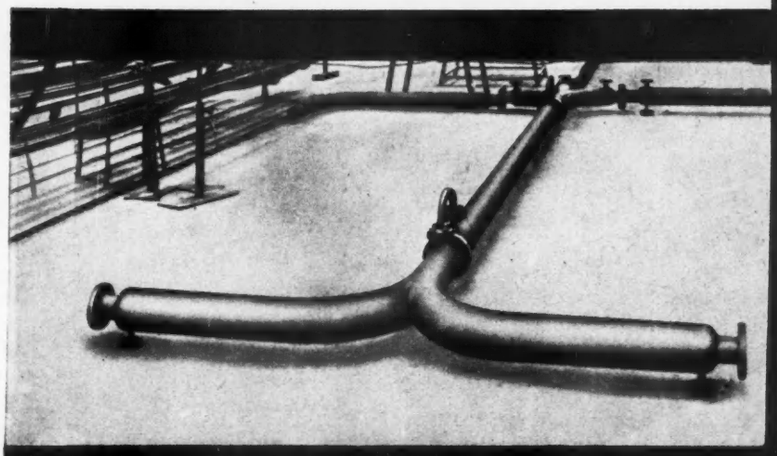


Fire bending process on a large bore steel pipe.



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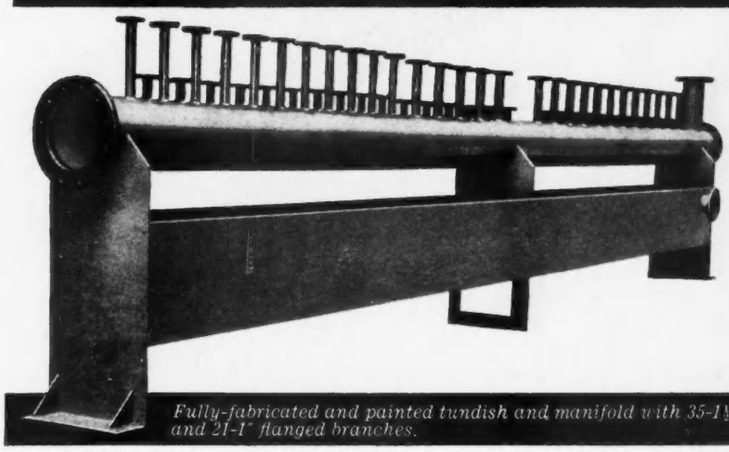
Bonn's Bending Machine installed in one of our bays in full operation



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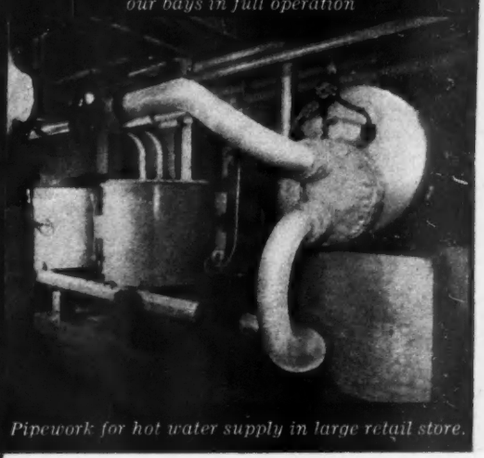

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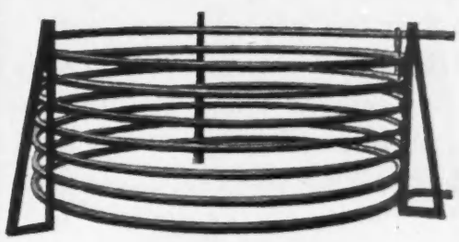

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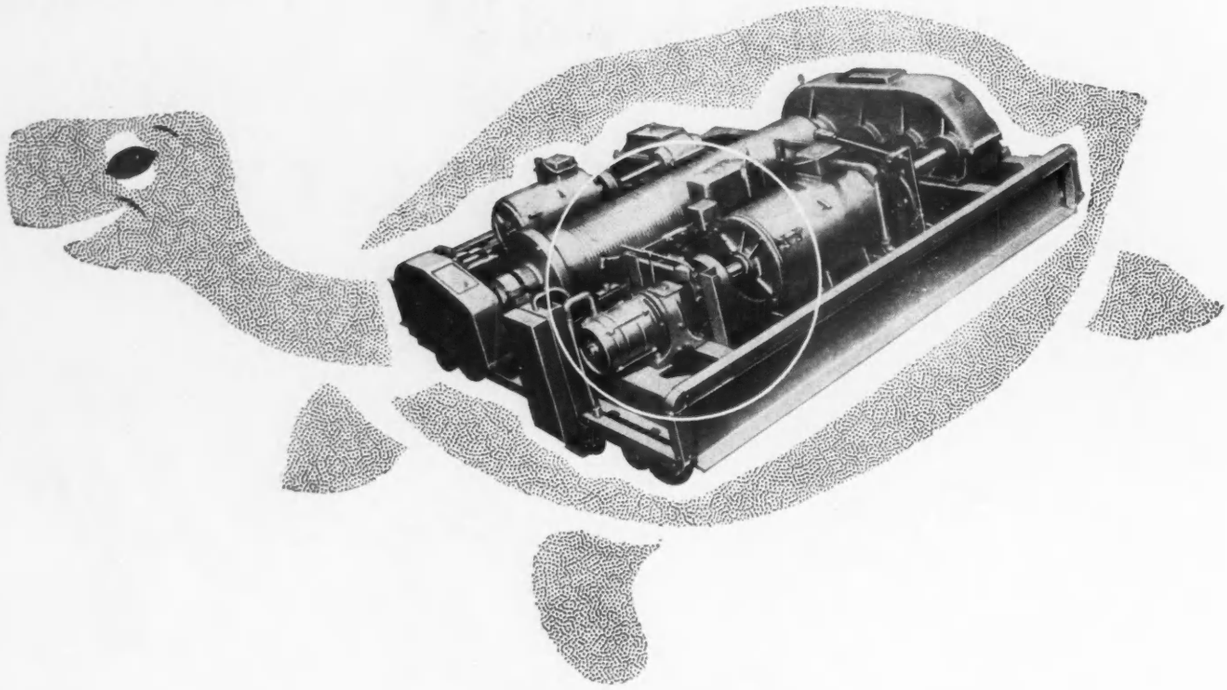

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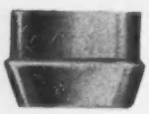

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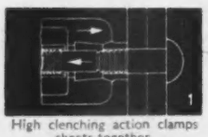
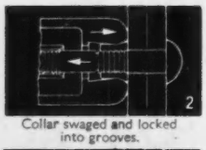
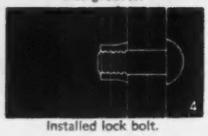


High clenching action clamps sheets together.



Collar swaged and locked into grooves.

Bolt breaks at breakneck groove.



Installed lock bolt.

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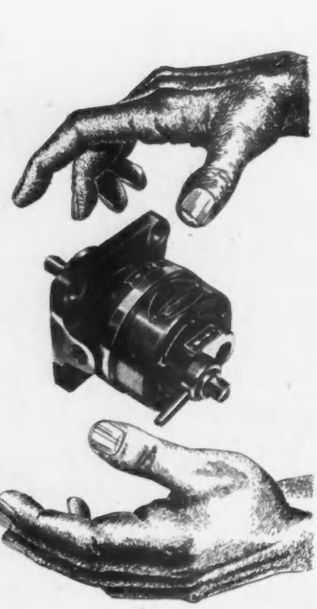

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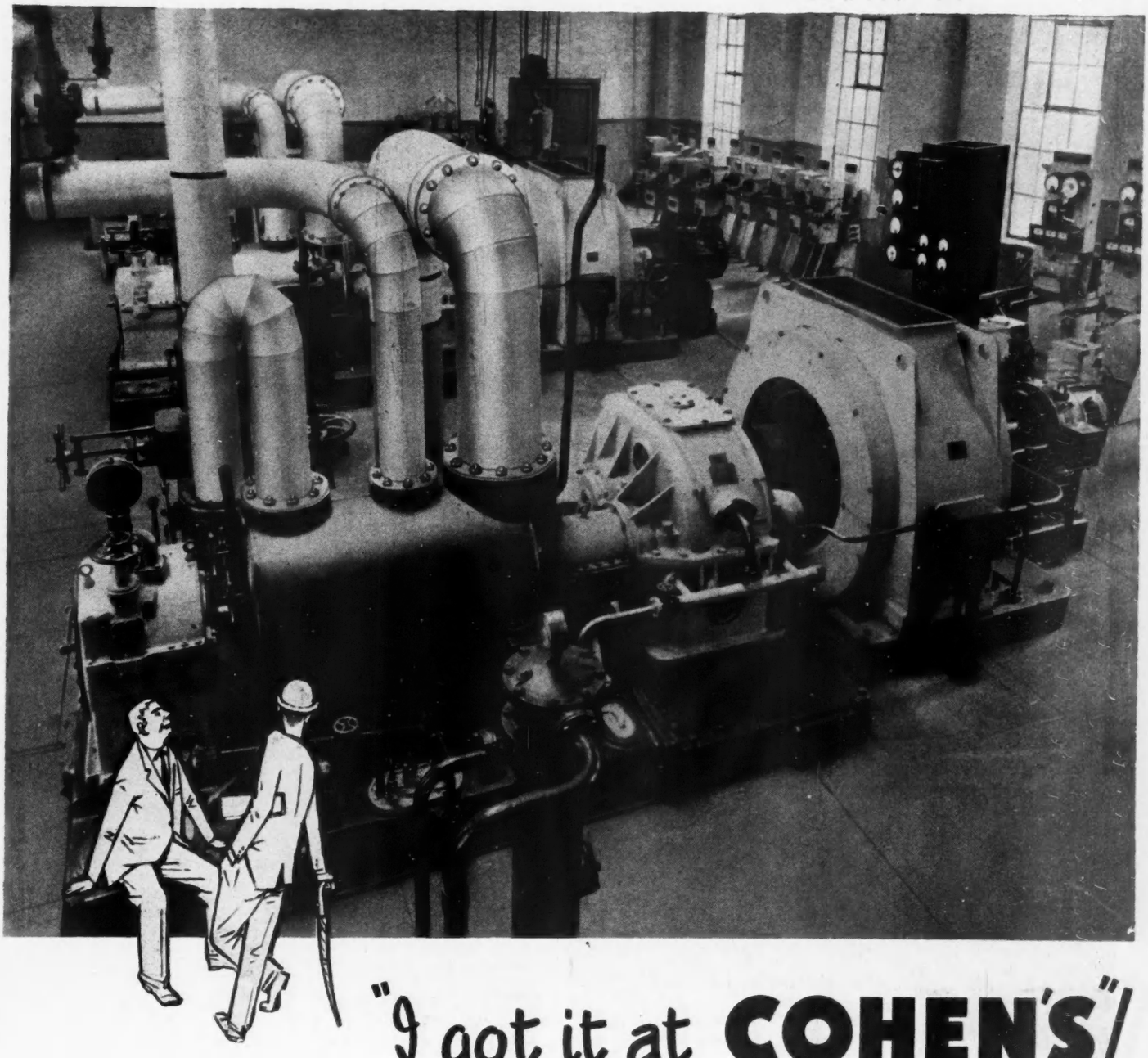

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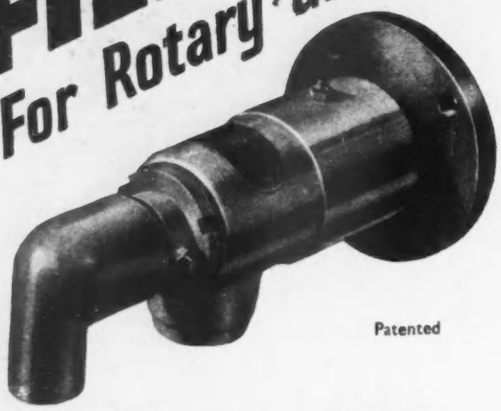

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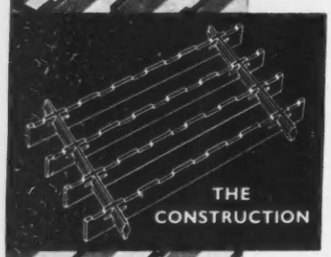

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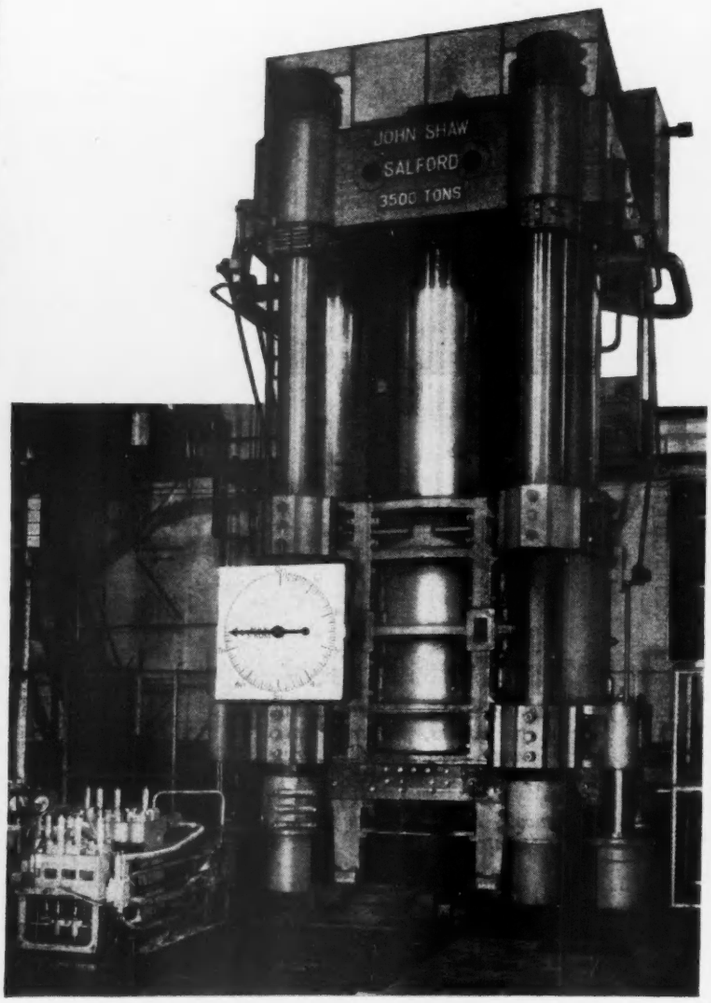
For whatever purpose you need a hydraulic press you will do well to consult JOHN SHAW.



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THE pigs, of course, couldn't care less, but the farmer's wife finds it amazing that Crane giant valves help to keep them well fed. However at the Pfizer Organisation, a large chemical producing factory, there is a department specialising in preparations used in pig feeding. And here these valves are performing vital duties during the early processing stages. The industries which Crane giant valves serve are varied and numerous . . . and the giant valve is only one among a wide variety of Crane valves—ranging from ⅛" to 24"—each with a tradition of reliable, efficient service. Crane's reputation for reliability lies in their high standard of design, production and precision testing methods.

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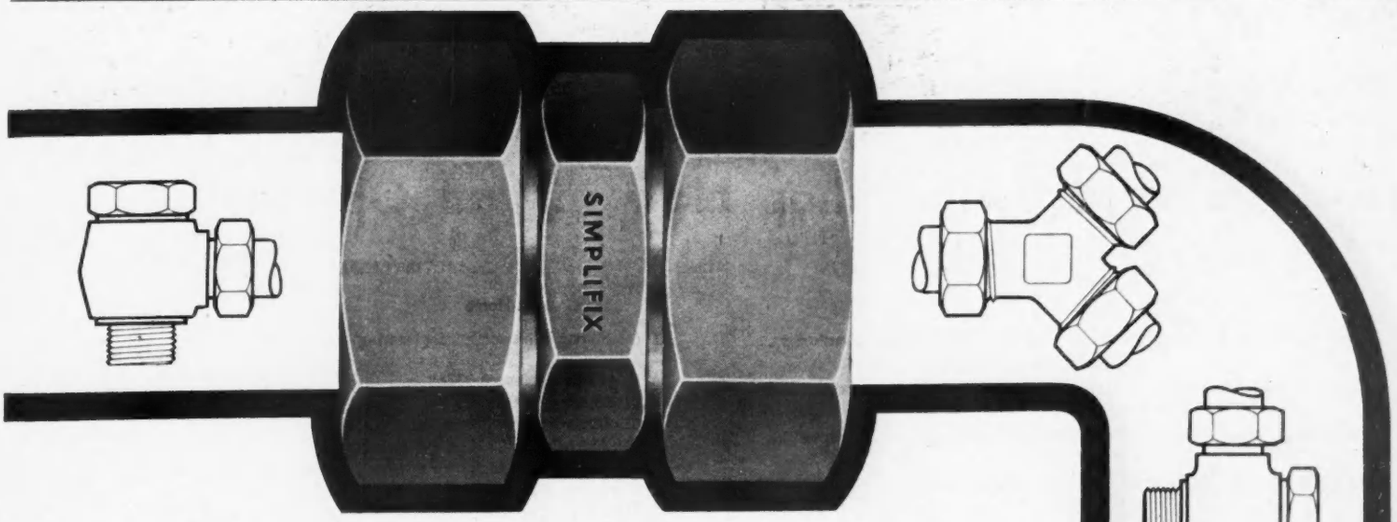

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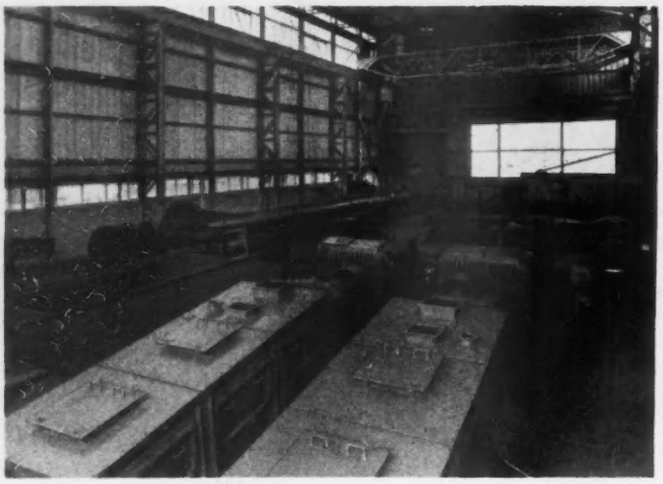

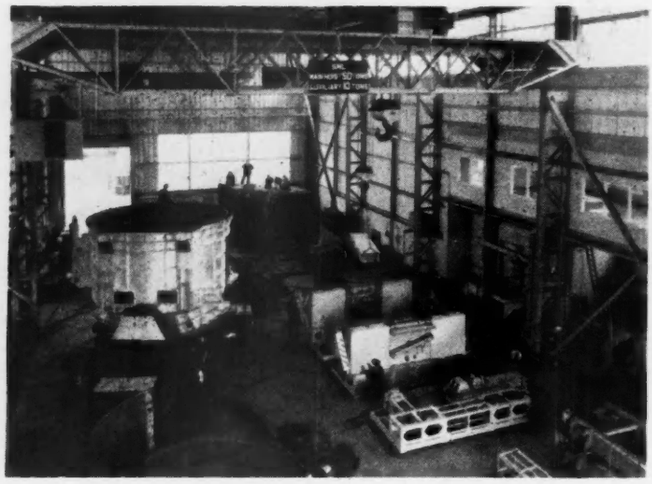

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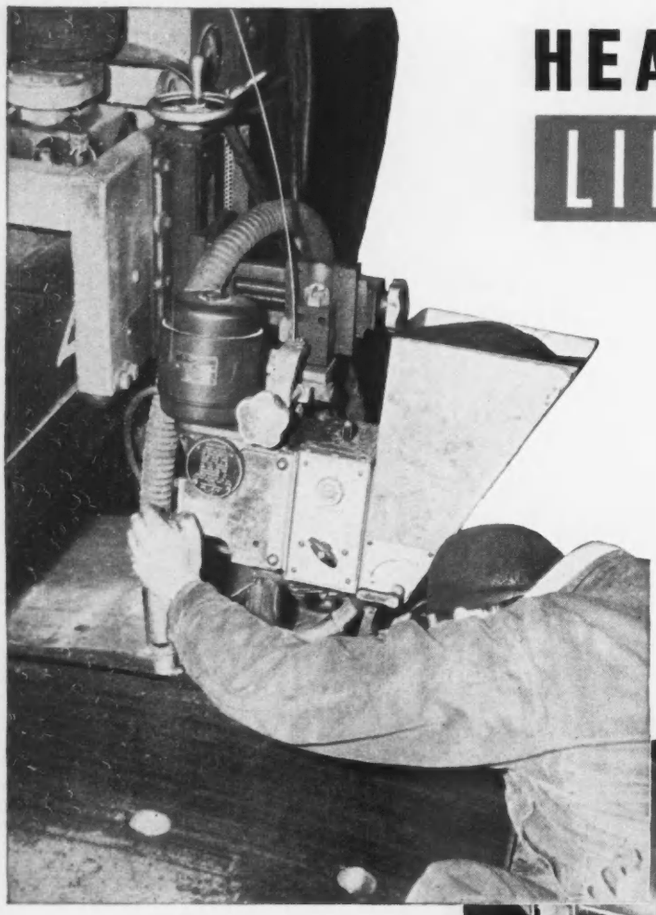


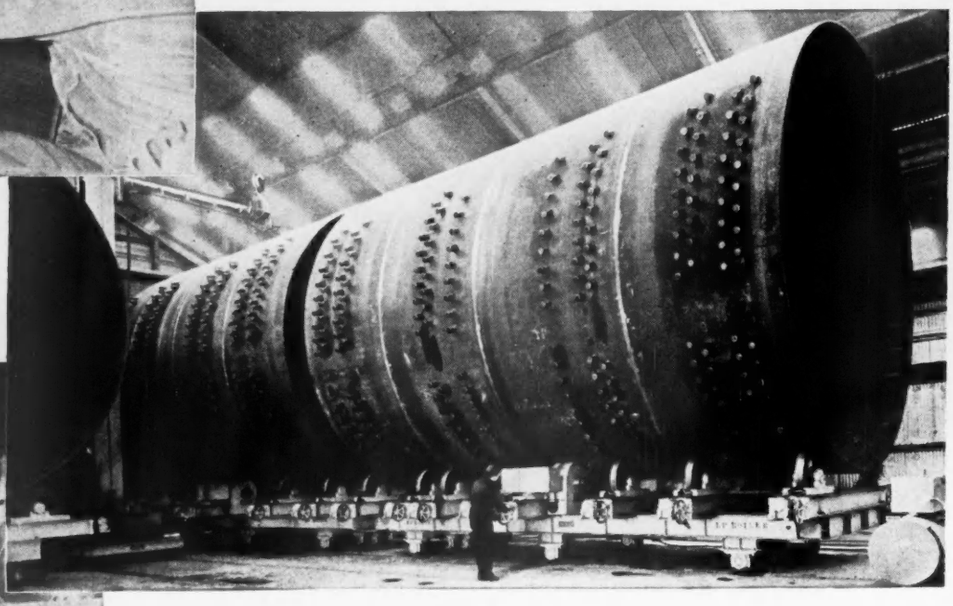
HEAT EXCHANGERS
LINCOLNWELDED

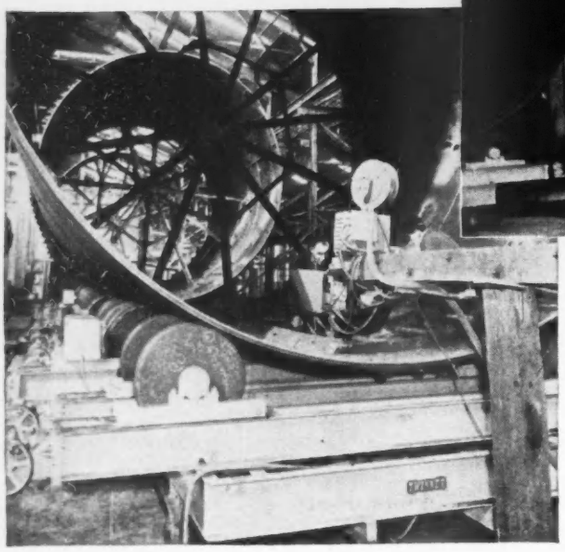
For Bradwell Nuclear Power Station, Essex

The 12 heat exchangers for Bradwell Nuclear Power Station, Essex, each weighing 200 tons, are being designed and fabricated by Head Wrightson & Co. Ltd., a member of the Nuclear Power Plant Company Limited, using IO LINCOLNWELD Fully Automatic submerged-arc welding units.

The vessels are subject to the requirements of Lloyd's Class 1 Standards for fusion welded pressure vessels, and all the welds are radiographically examined, and finally stress-relieved.

The above photograph shows a close up view of a LINCOLNWELD Fully Automatic submerged-arc welding unit, working on an external weld.





The photographs show *(Above)* the completed shell of the first exchanger. *(Left)* an internal weld being made with a LINCOLNWELD Fully Automatic submerged-arc welding unit.

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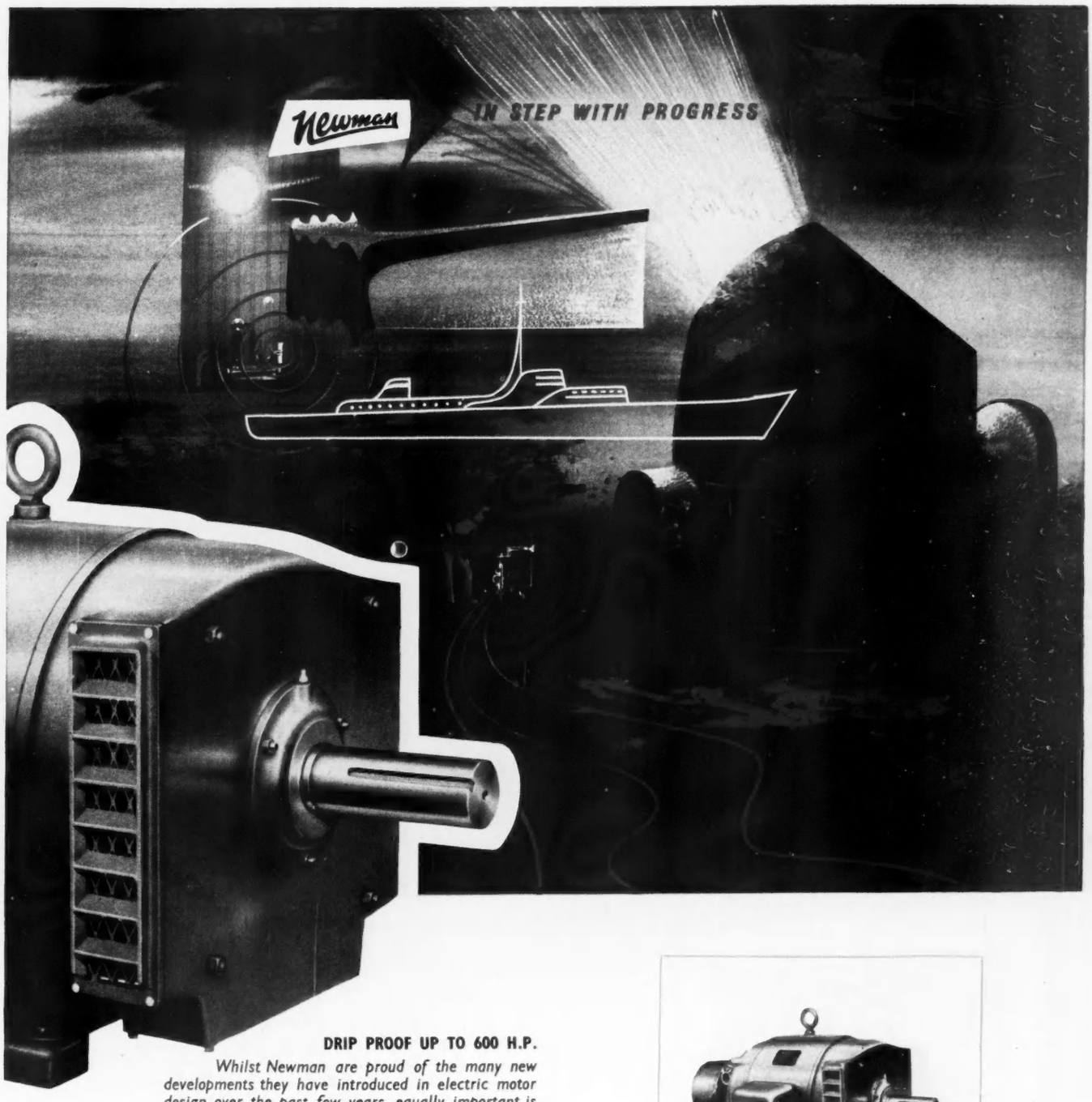

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Whilst Newman are proud of the many new developments they have introduced in electric motor design over the past few years, equally important is the progress the Company has made in extending its existing ranges.

An important step has been the addition of larger frames to the standard drip-proof range. Newman can now supply drip-proof, squirrel cage motors from 1/6—600 h.p.

YET ANOTHER EXAMPLE OF THE NEWMAN PROGRESSIVE DESIGN POLICY.

Newman

making the pace in motor progress

NEWMAN INDUSTRIES LIMITED, YATE, BRISTOL, ENGLAND

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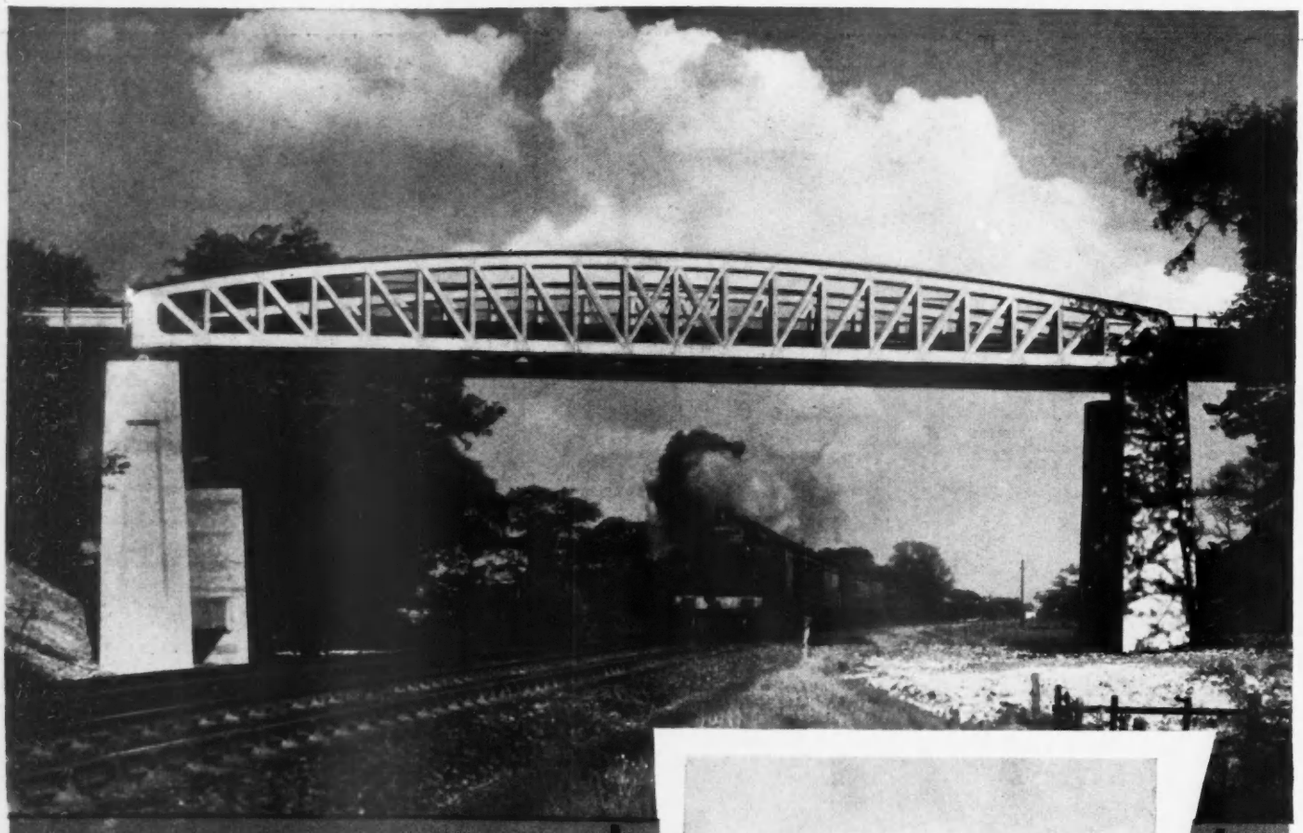

Bridges by

BUTTERLEY

Hampole Viaduct is situated on the Denaby Branch of the Hull and Barnsley Line, and carries the track over the Wakefield-Doncaster Line. The new bridge replaces a five-span brick arch viaduct and the work was carried out for the North Eastern Region of British Railways. (Chief Civil Engineer, A. Dean, Esq., M.I.C.E.)

The two approach spans have welded main girders with a steel and concrete deck. The centre span utilises lattice girders supplied by the B.T.C.; these were repaired and modified to take new cross girders and railbearers. The main contractors were Harbour and General Works, Ltd.

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B 44

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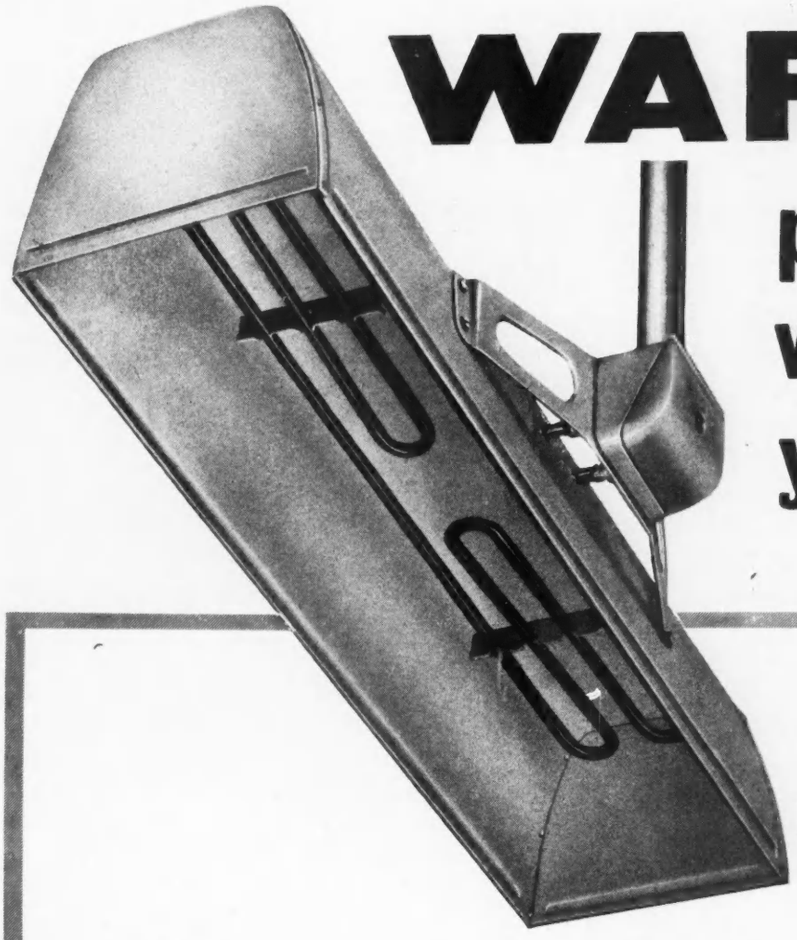
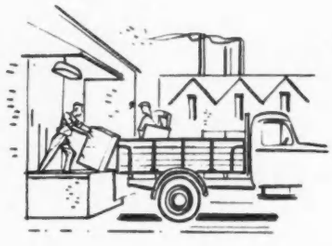
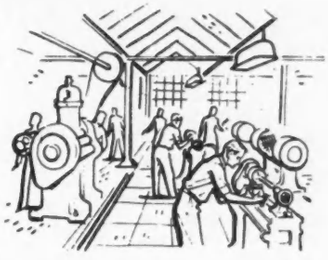
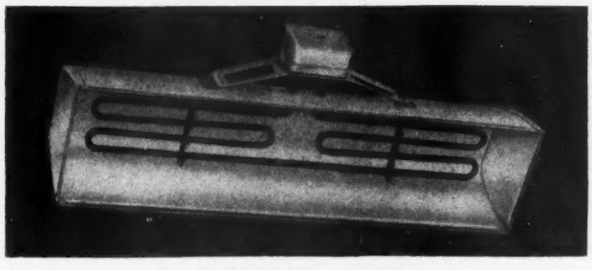


METROVICK
Radiant Space Heater





Radiant space heating is the new idea for providing warmth for people at work, waiting in queues, watching games, shopping, etc. Thus in a large building it is possible to direct heat to just those areas where operatives are working.



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The Metrovick radiant space heater consists of an anodised aluminium reflector with a tubular sheathed heating element rated at 3 kW at specified single phase voltages. It weighs under 5 lb. and is easily erected on a single 1 in. conduit from the die-cast aluminium alloy weather-proof terminal box.

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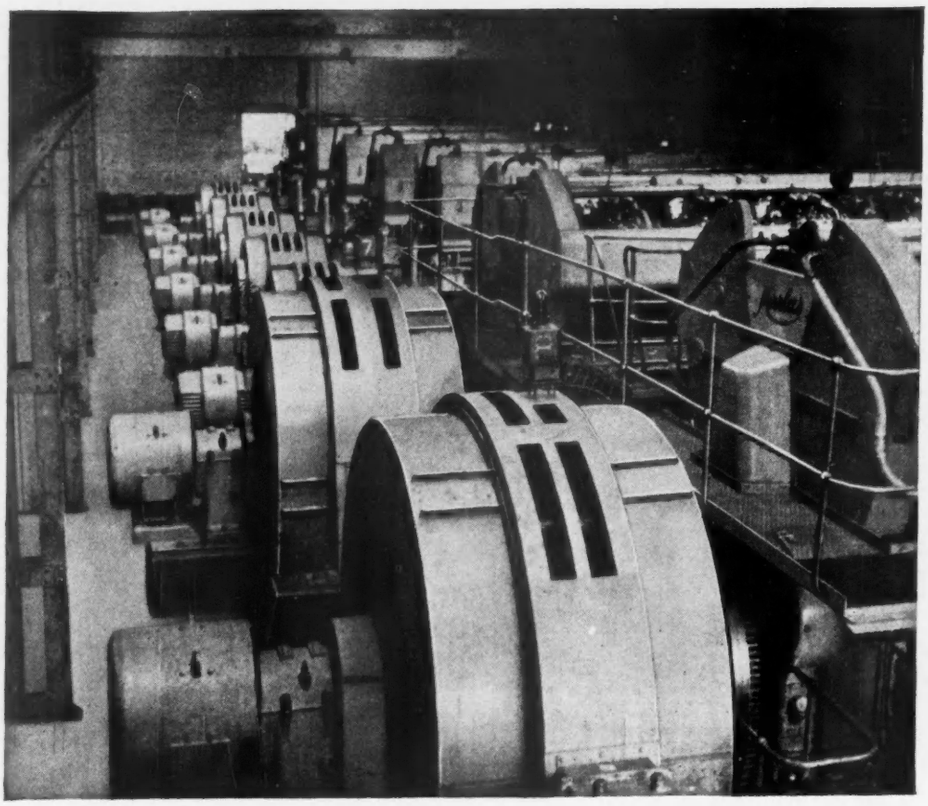

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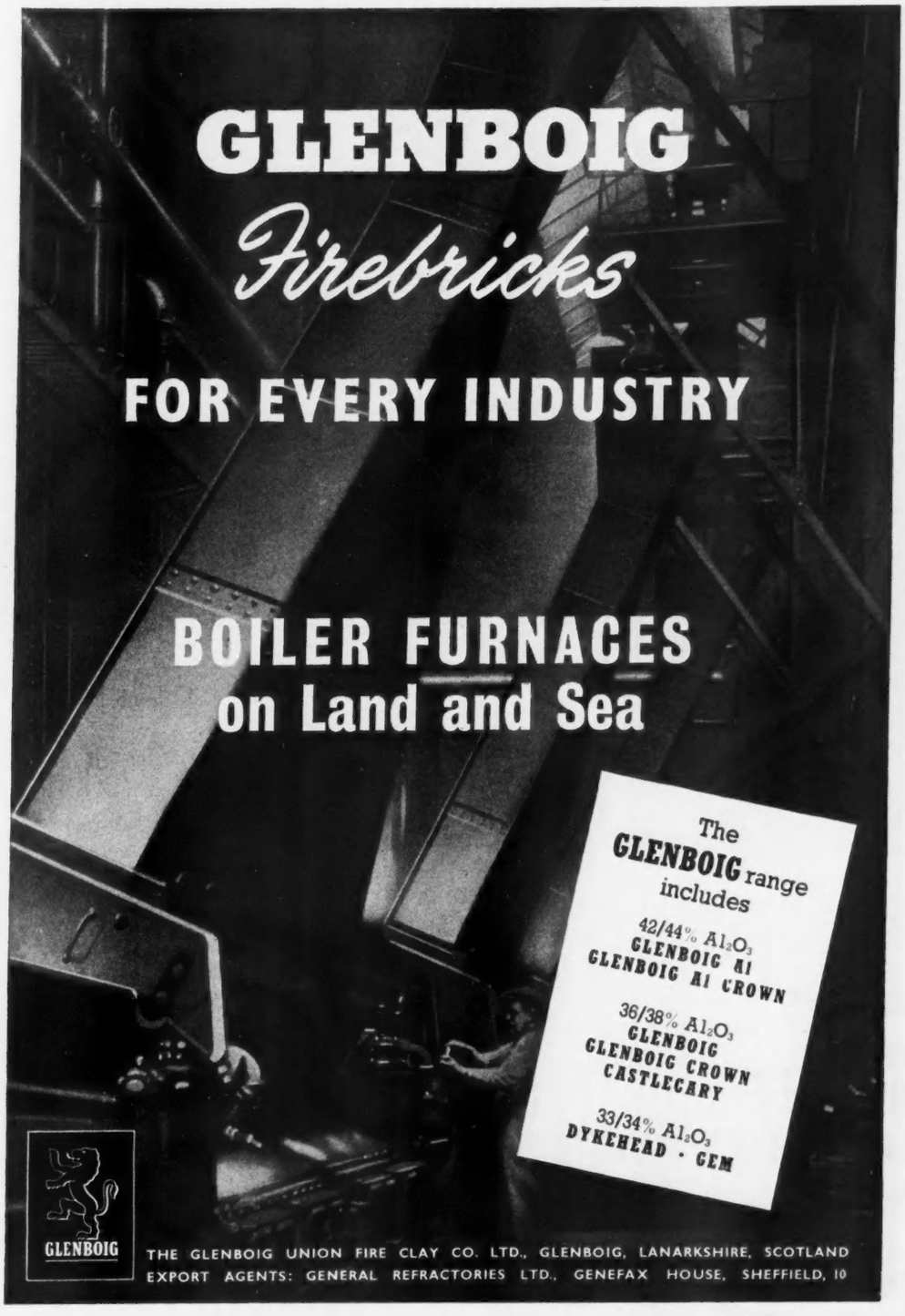

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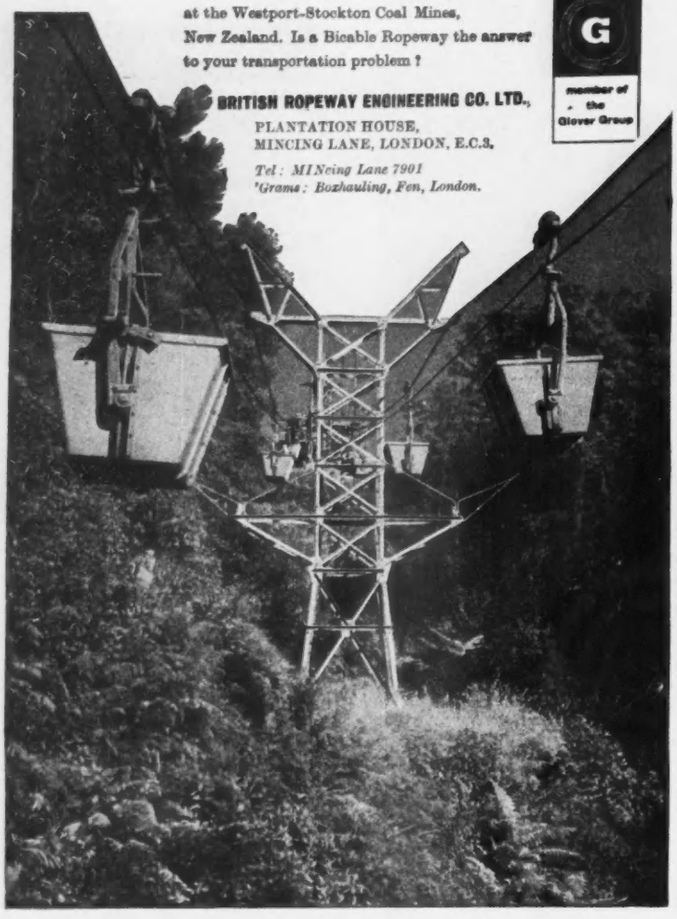

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PHOTOGRAPH BY COURTESY OF MESSRS. HOOVER LTD.

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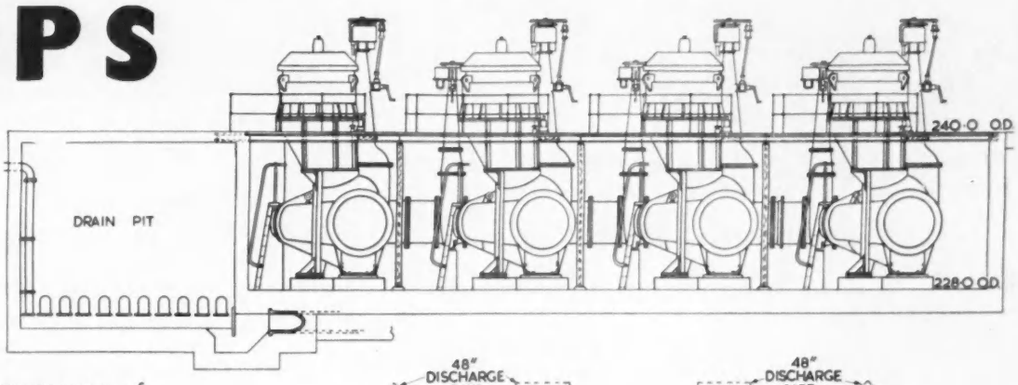
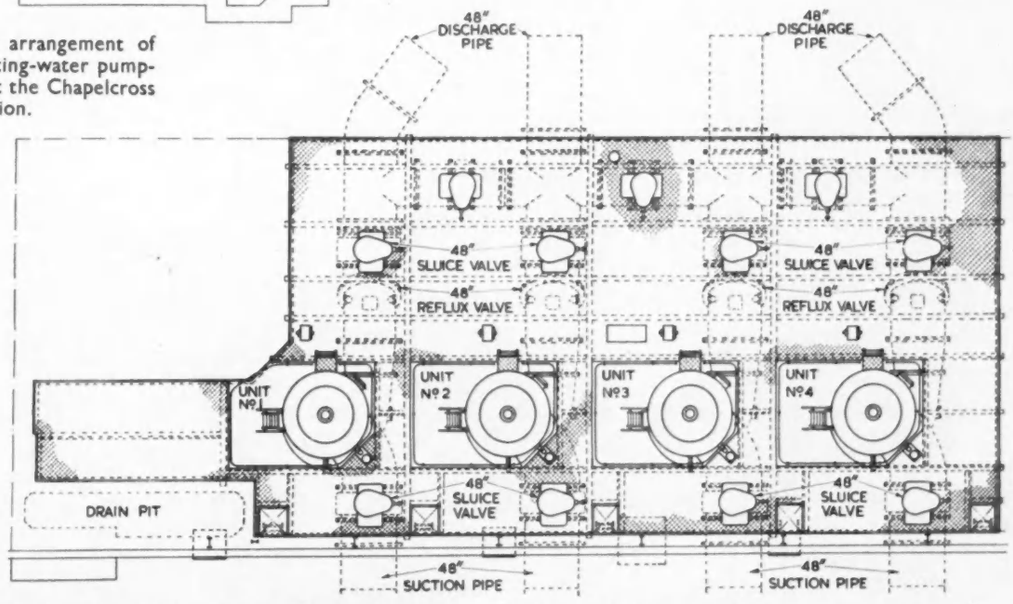


Installation arrangement of the circulating-water pumping units at the Chapelcross Power Station.



for the

CHAPELCROSS POWER STATION of the UNITED KINGDOM ATOMIC ENERGY AUTHORITY

Consulting Engineers : MERZ AND MCLELLAN

The installation comprises four Allen 48/48-in. vertical double-suction centrifugal pumps, each designed to deliver 50,000 gallons of water per minute against a total head of 67 feet, running at a speed of 490 r.p.m., and driven by a 1225-h.p. L.S.E. motor.

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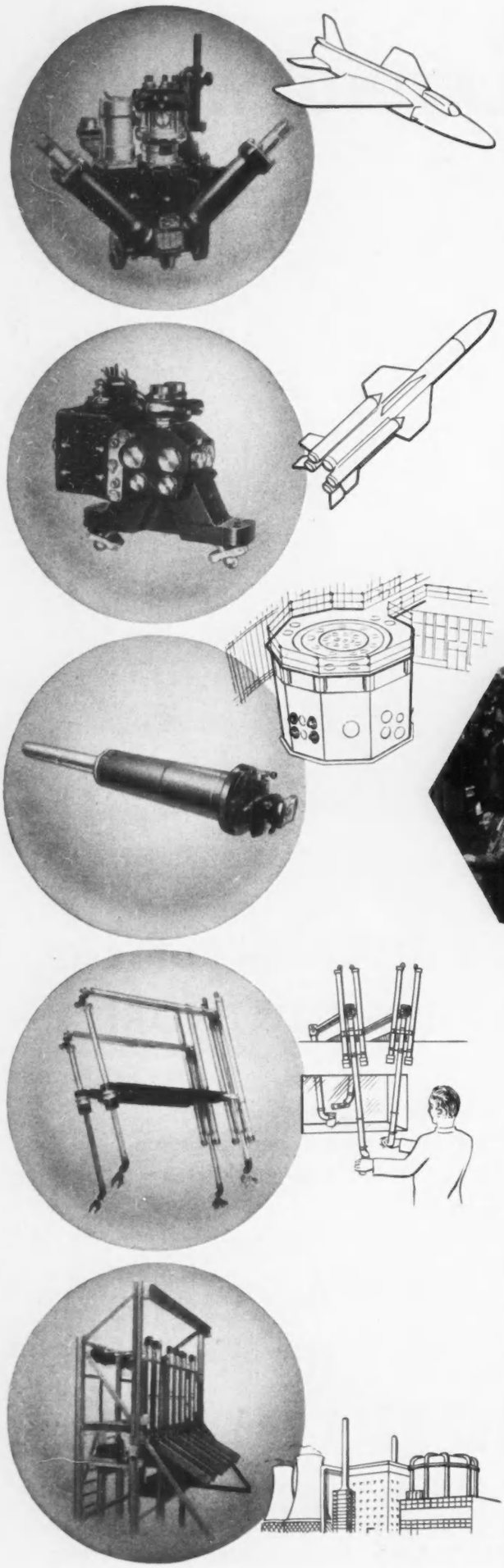

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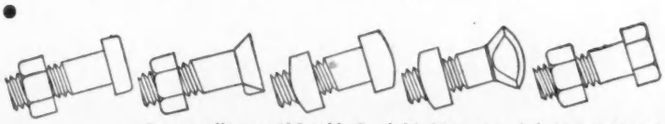
Hexagon and fiddle heads, Square heads, rare heads, countersunk and cheese.

Round necks, square necks, strength-enough-to-spare necks, oval necks, novel necks —even more than these.

The Lanarkshire range of standard bolts and nuts available from stock is quite staggering. Materials range through conventional black, bright, and brass to copper, stainless steel, and the special application bronze alloys.

Specials? Certainly! And with very little delay.



Buyers tell us our 'Monthly Stock List' is a great help in requisitioning. If you aren't yet receiving a copy, just send your name and address to

LANARKSHIRE BOLT LIMITED

HAMILTON · LANARKSHIRE · SCOTLAND
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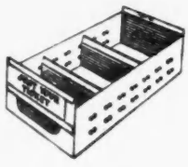


54 drawers like this make up our popular all-steel "54" DRAWER UNIT

DRAWER SIZE
11¼" long, 5" wide, 3" high

OVERALL SIZE
42" high, 36" wide, 12" deep

Each drawer perforated, and with one free divider. or plain sided.

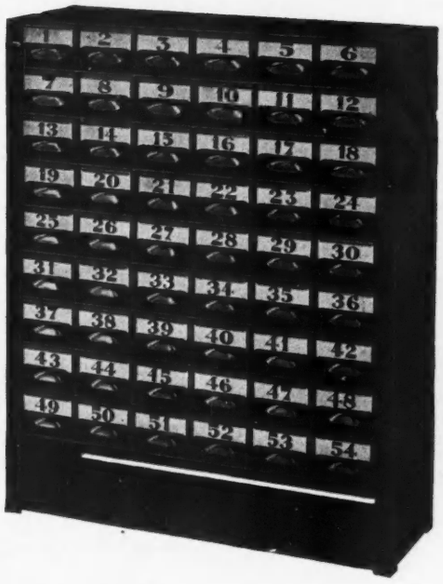
Extra dividers 6d. each. 54 cards free.

STOVE ENAMELLED DARK GREEN

£18 . 0
DELIVERED FREE TO ENGLAND, SCOTLAND AND WALES.

Delivery from stock

SEND FOR SAMPLE DRAWER WITHOUT OBLIGATION



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HEYWOOD, LANCS. Tel: 69018 (3 lines)

Stop that water waste!

with Prestex non-concussive spring taps

Thousands of gallons of water may trickle away in large public buildings, factories, schools, hotels and ships from taps not turned off completely. Hot water, especially, is expensive.

Prestex non-concussive spring taps are a sure answer to this costly irresponsibility, a big problem *particularly* shown in its true light in times of drought. Models available include:

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(with the NEW '3D' style button top)
½" Pillarcock. 3" nose and tail.

- Non-concussive self-closing action
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- Self-regulating to any pressure up to 100 lb. per sq. in. Each tap fully tested on water pressure
- As easy to re-washer as an ordinary tap
- Chromium finish on a heavy nickel base

Approved by all large Water Authorities.

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Giants of the West

Sinister rumours cloud the memory of the Giant of Trebiggan. But with those enormous arms of his — and the robust humour that was fashionable in his day — temptation must have been great. If he did sometimes restore his giant's strength with a fat baby for breakfast, the sailors he snatched from ships struggling past Lands End weren't always treated so summarily. After enjoying his joke to the full, he would occasionally put one back again . . .

Things still have to be lifted from ships by giant strength and reach, but the modern giants – the kind that S & H build – are predictable creations which draw their energy from more humane sources.

Strachan and Henshaw Ltd

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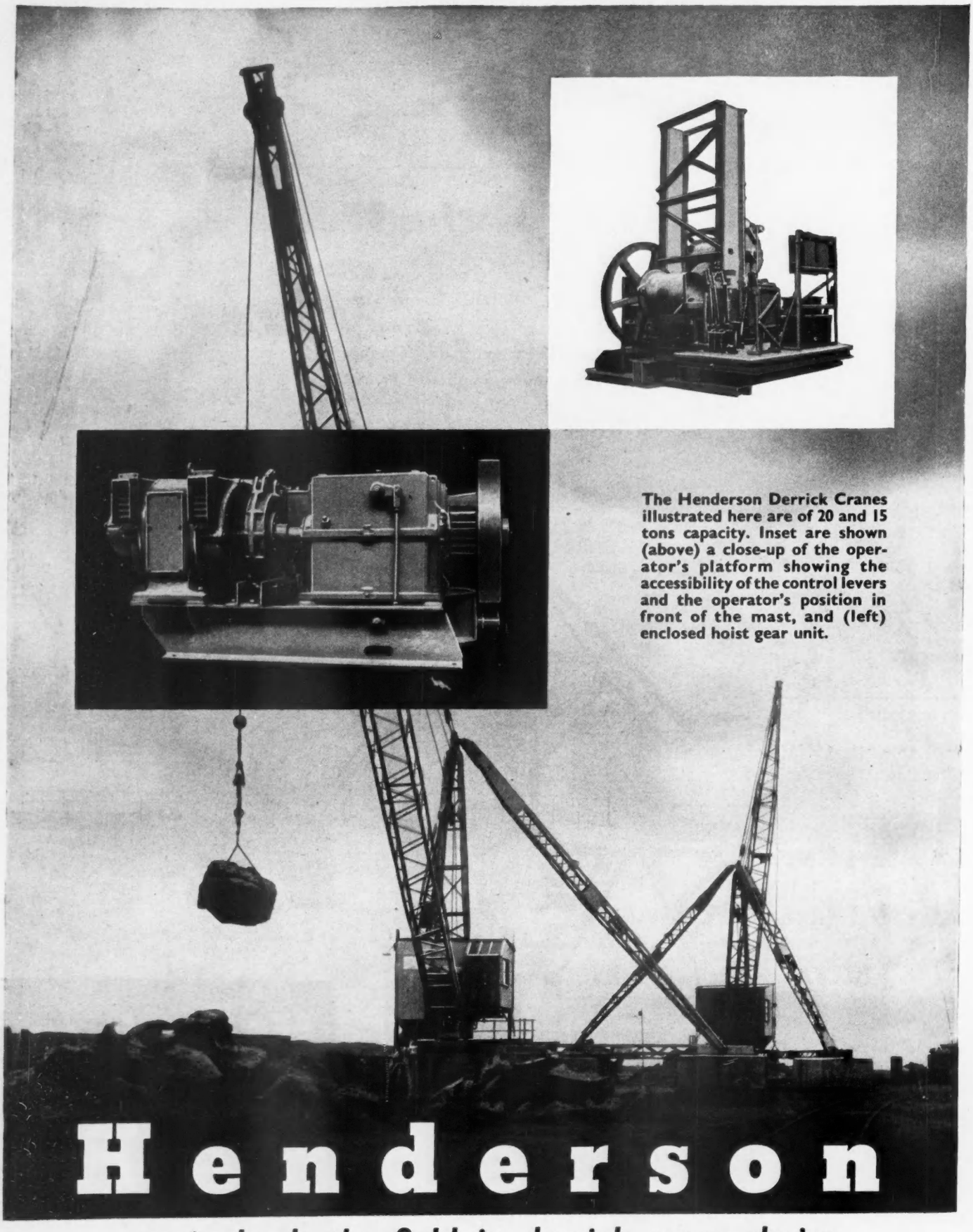

The Henderson Derrick Cranes illustrated here are of 20 and 15 tons capacity. Inset are shown (above) a close-up of the operator's platform showing the accessibility of the control levers and the operator's position in front of the mast, and (left) enclosed hoist gear unit.

Henderson

again leads the field in derrick crane design

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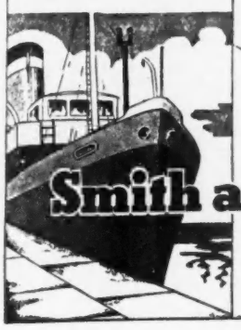
Metals deposited include: Zinc, Tin, Aluminium, Copper and all its alloys, Cadmium, Monel Metal, etc.



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NOTHING GETS PAST Hallprene

Hallprene

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High pressure sealing over long periods is ensured by Hallprene Patent Fluid Seals. These seals overcome certain disadvantages of normal "U" type packing rings. Handling damage and inward collapse of the sealing lips is prevented by a soft, pliable synthetic rubber filling. Under pressure, this filling forces out the walls, ensuring a perfect seal.

Hallprene Patent Fluid seals are impervious to the action of hydraulic fluids.

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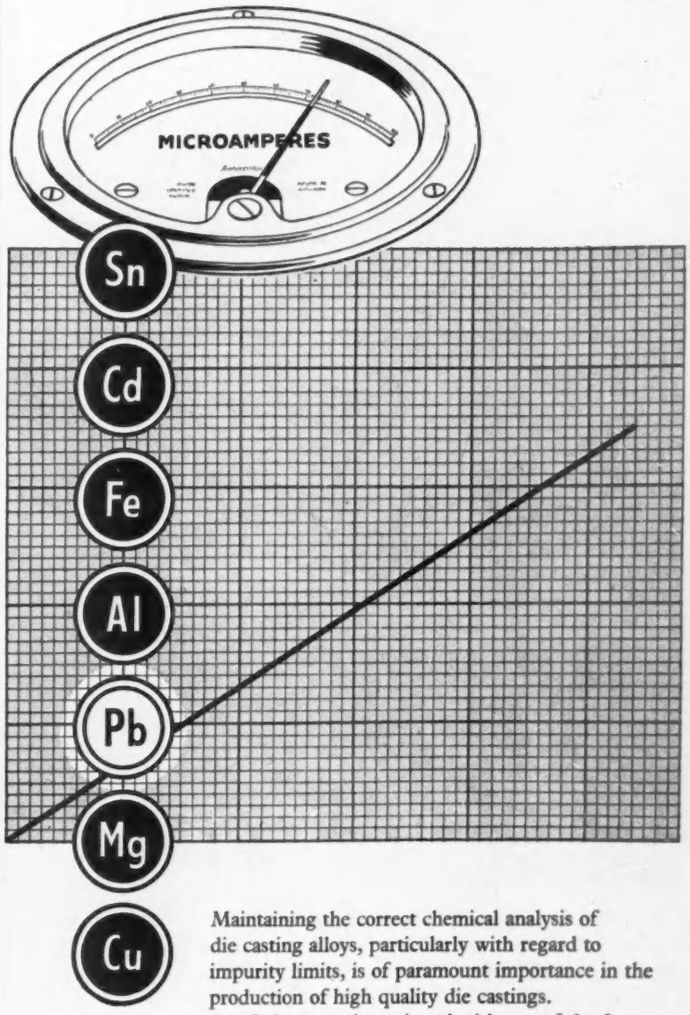
P329

QUALITY CONTROL of pressure die castings



Maintaining the correct chemical analysis of die casting alloys, particularly with regard to impurity limits, is of paramount importance in the production of high quality die castings.
Our Laboratory is equipped with one of the few *direct reading spectrographs* in use in this country.

As a result the requirements of the B.S.I. Certification Scheme for zinc alloy die castings are far exceeded. Every melt is analysed and the holding furnace of every machine is checked for impurities at least once per shift, enabling any variance from specification to be quickly identified.

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IN ZINC, ALUMINIUM AND SOFT ALLOYS

SPARKLETS LIMITED

DIE CASTING DIVISION

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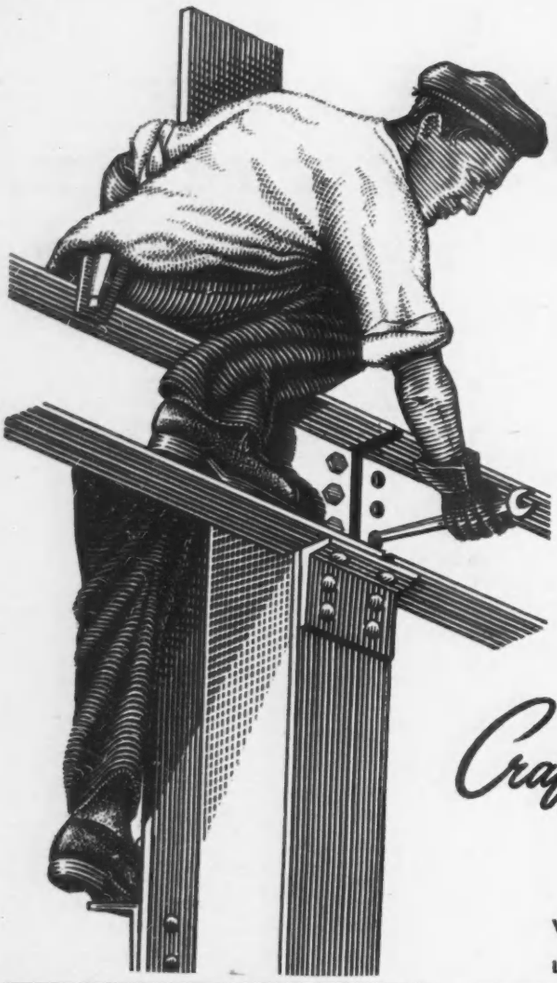

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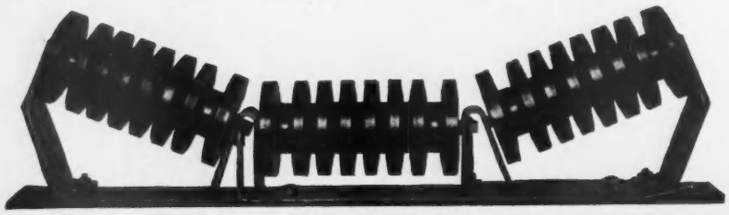

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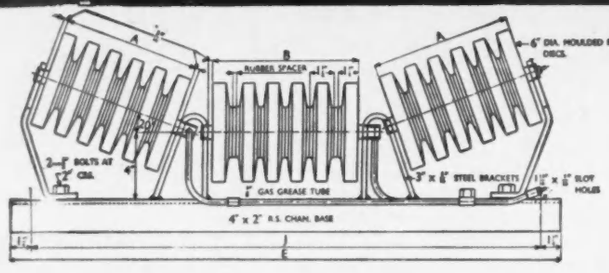
Cut replacement costs

Conveyor belts are expensive items. It has been proved that Westwood Dawes Rubber Disc type Impact Resisting Troughing Idlers reduce wear caused by the impact of heavy or abrasive material. It will pay you to fit these resilient idlers at all points of strain and at all loading and transfer points where wear is constant and the going tough.

IMPACT IDLERS PROTECT YOUR CONVEYOR BELTING!



SIZE	A	B	L	
12" BELT	5"	8"	22"	19"
14" "	5"	8"	24"	21"
15" "	5"	9"	25"	22"
16" "	5"	8"	26"	23"
18" "	6"	9"	28"	25"
20" "	7"	8"	30"	27"
22" "	7"	9"	32"	29"
24" "	8"	9"	34"	31"
26" "	8"	10"	36"	33"
28" "	10"	10"	38"	35"
30" "	10"	10"	40"	37"
36" "	12"	12"	46"	43"
42" "	15"	15"	52"	49"
48" "	17"	17"	58"	55"

We also manufacture:—
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Finished machined forgings

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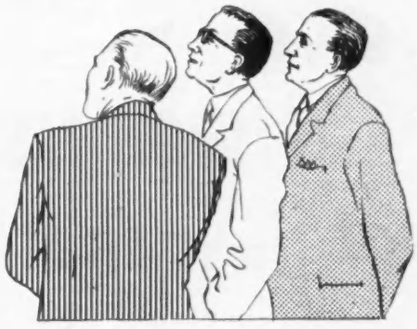

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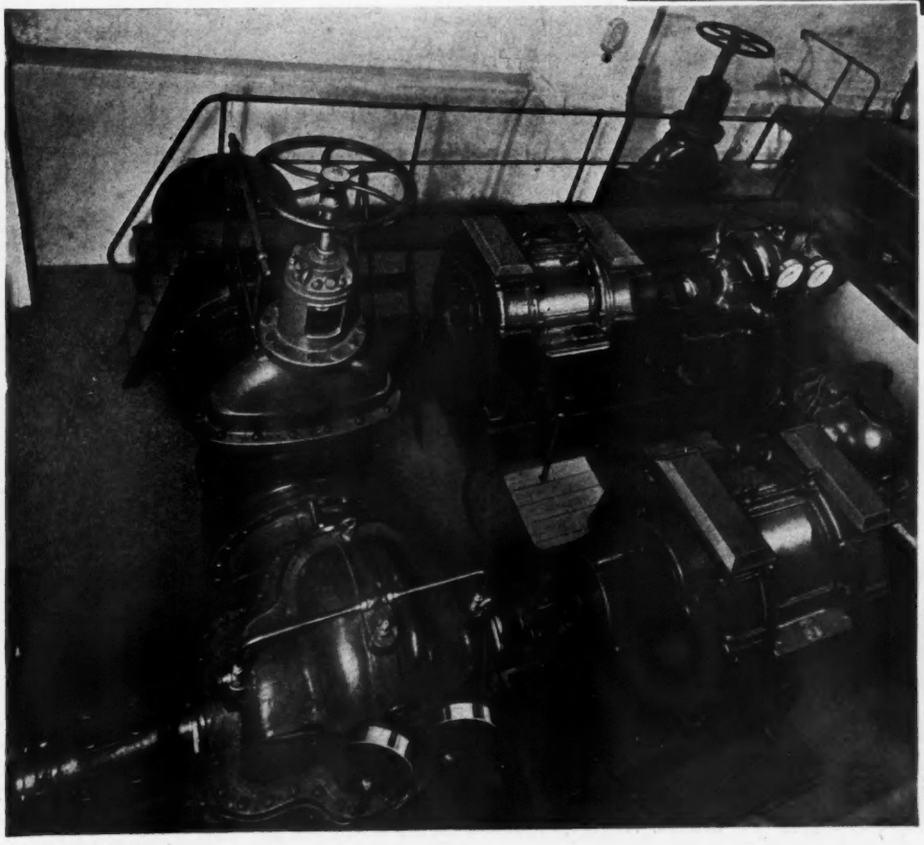

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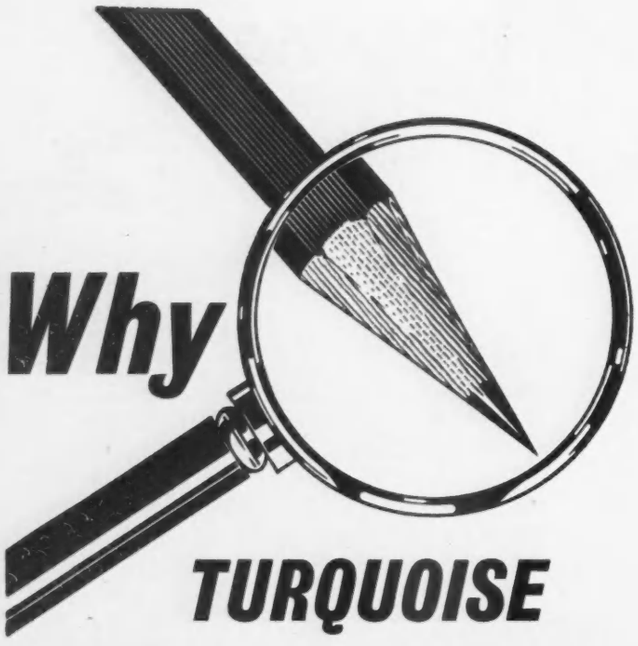

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The lead in Turquoise pencils is something quite special. It is prepared from 100% electronic graphite, which after being cleansed of all impurities is spun to particles of 1/25,000 of an inch, then blended with clay and steeped in hot waxes.
A finer, more compact lead structure results, because millions more minute graphite particles are compressed into every inch of lead.

This lead structure makes Turquoise the most reliable pencil you can use. It ensures exceptional smoothness—this eases your work. It means less wear and greater resistance to point breakage—this saves time and money. It means denser, more opaque lines for cleaner, sharper reproductions.

NOW ALSO AVAILABLE Turquoise drawing leads 2B to 6H

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'CHEMI•SEALED' Super-bonded

TURQUOISE DRAWING PENCILS

with 100% 'ELECTRONIC' Graphite

T14A

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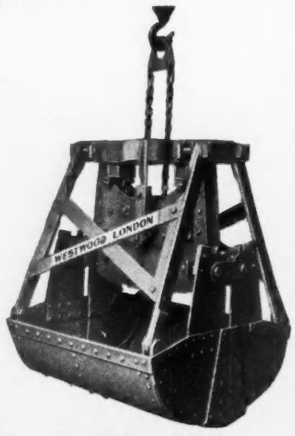
MECHANICAL GRABS

Illustrated is the Single Chain, self-dumping grab which is particularly suitable for handling coal, sand, ballast, etc.



Illustrated is the Twin Chain, Self-Dumping Grab which is particularly suitable for handling coal and similar materials where headroom is restricted.

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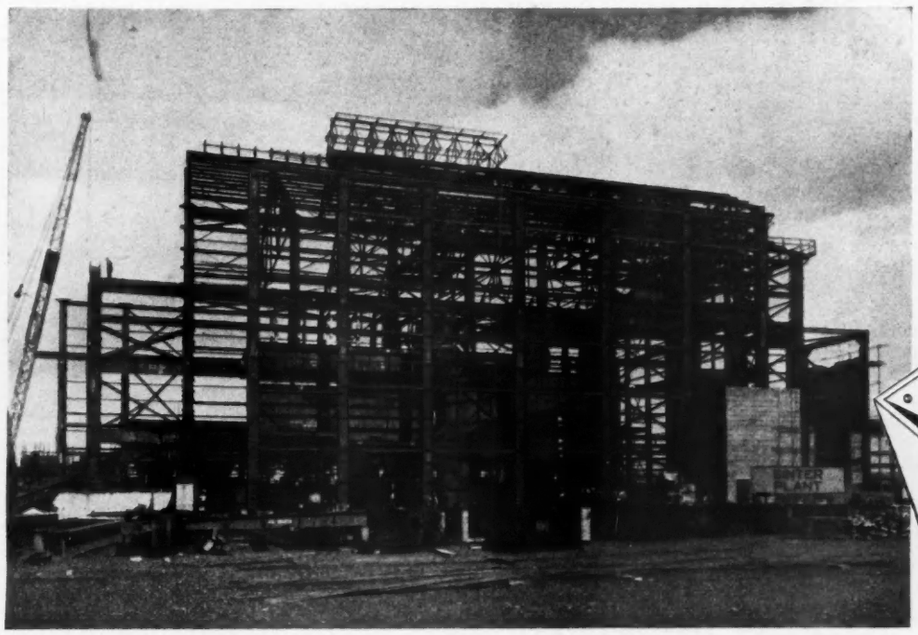
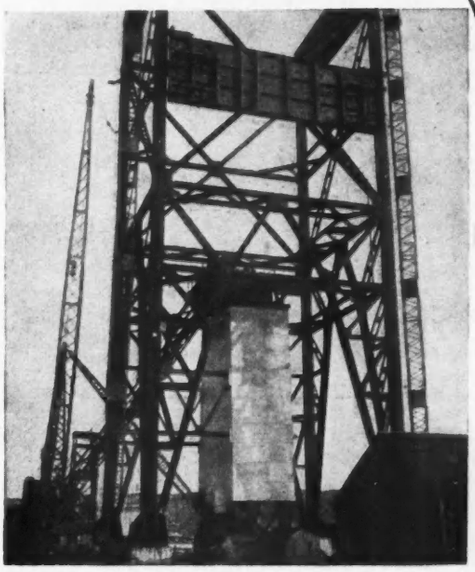
construction in steel



The constructional Department of Head Wrightson produces steelwork for industrial constructions of all types, chemical, gas, iron and steel, etc. The lower photograph shows the 200 ft. Winder Tower built for the Rufford Colliery of the National Coal Board. 750 tons of steel were used in this construction. The illustration above shows the Sinter Plant Building constructed for Messrs. John Summers & Co. Ltd.



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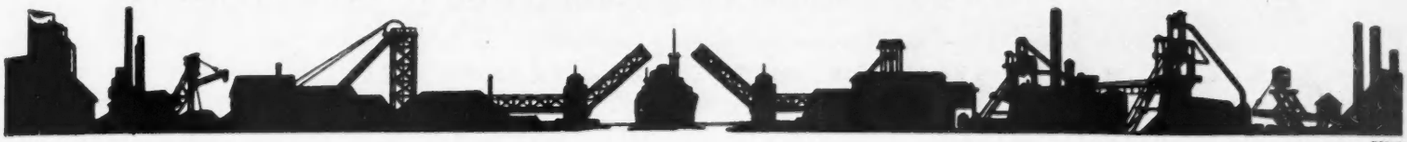
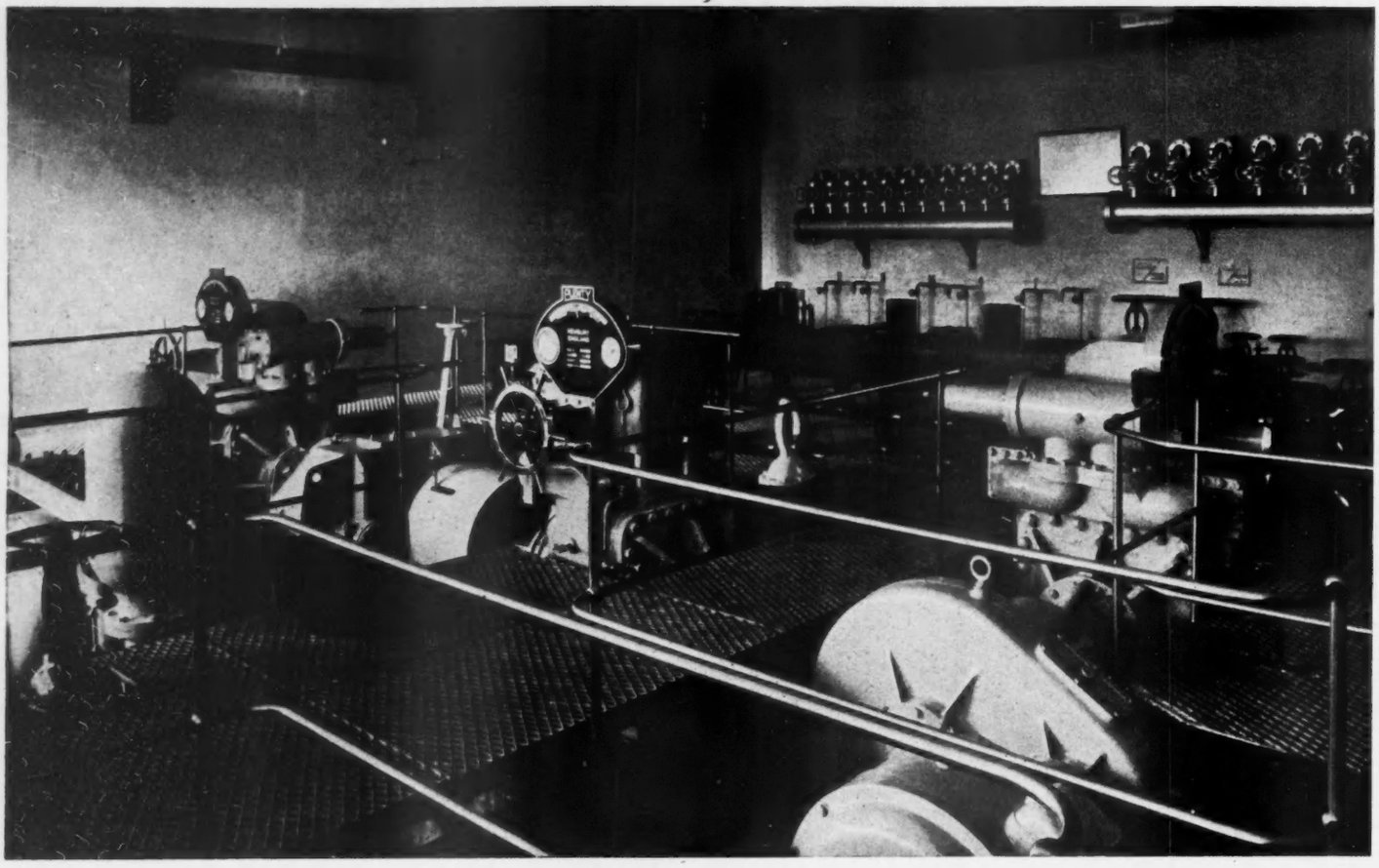
TEESDALE IRON WORKS THORNABY-ON-TEES

LONDON JOHANNESBURG TORONTO SYDNEY CALCUTTA



BLENDING . . .



in the OIL INDUSTRY

Shown above are three 200-ton per hour Plenty Variable and Reversible Delivery Pumps installed at the Bunkering Installation of BP Olie-Kompagniet A/S, Copenhagen. These pumps handle all grades of oil from Diesel to heavy bunker fuel and can easily and quickly be set to deliver any predetermined grade of fuel oil by the blending of light and heavy base stocks. They maintain accurate blend irrespective of temperature, throughput or pressure head, without any elaborate or delicate apparatus.

Variable and reversible delivery pumps of the Plenty type enable lines to be purged or drained and transfer duties to be carried out with constant speed unidirectional prime movers, without elaborate changeover connections and valves. Plenty pumps are in use at the principal oil installations throughout the world, and can be supplied with automatic controls of all kinds and with remote control. They are made in sizes from 60 g.p.h. to 750 tons per hour, and catalogues are available covering all their various uses in industry.

NEWBURY **PLENTY & SON Ltd.** Berks, England

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MIXING MACHINES, FILTERS

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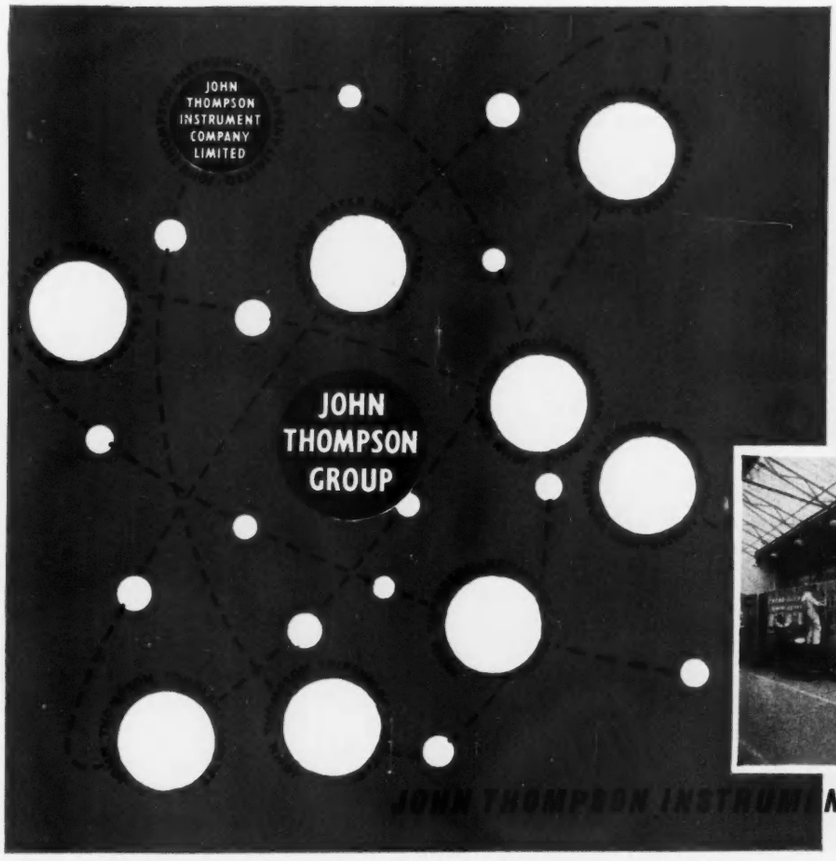
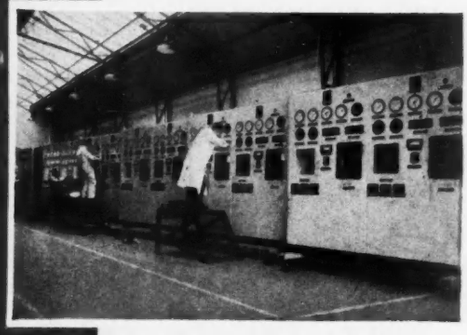


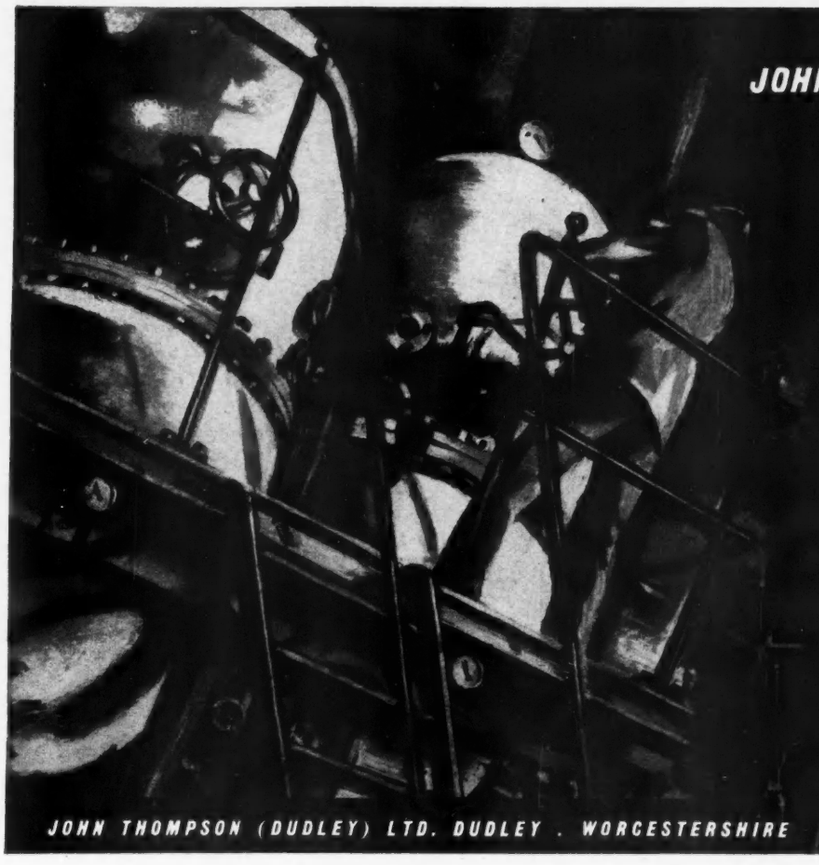
INSTRUMENTATION

In recently extended premises, the John Thompson Instrument Company Ltd. produces measuring, recording, and auto-controlling instruments and undertakes complete instrumentation including panelling, wiring and pipework for steam-raising, chemical process, foundry and nuclear power plant. Instrument panels seen here in course of production are for the Dounreay fast reactor heat exchange plant



JOHN THOMPSON INSTRUMENT COMPANY LIMITED
WOLVERHAMPTON

ING/1



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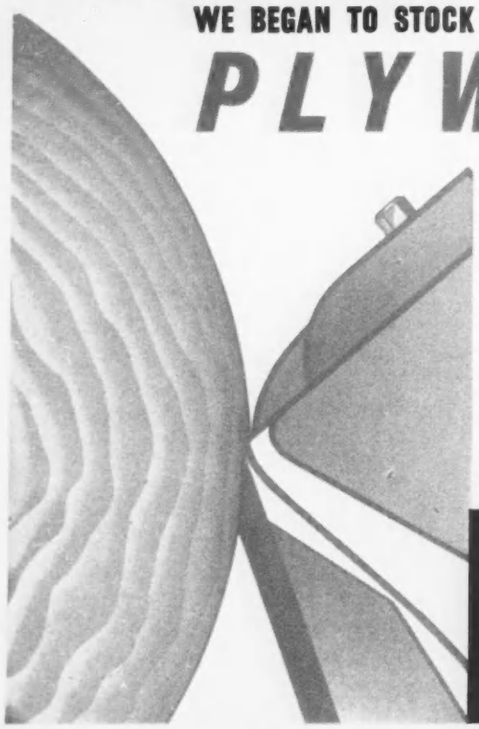

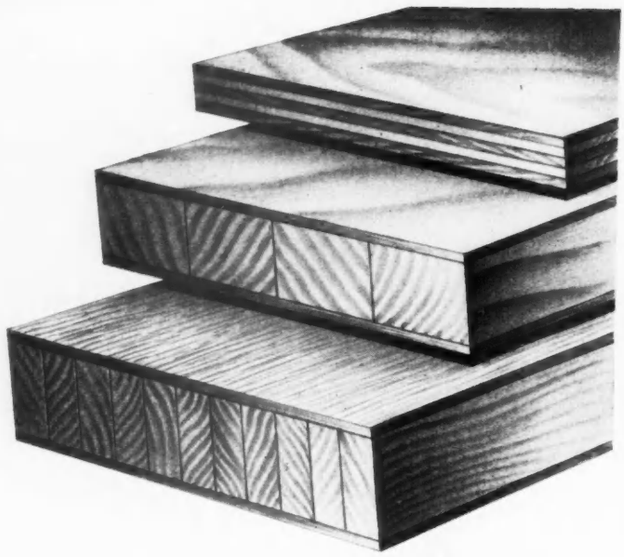

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from 16 m/m. to 25 m/m. (5/8" to 1")

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from 13 m/m. to 51 m/m. (1/2" to 2")

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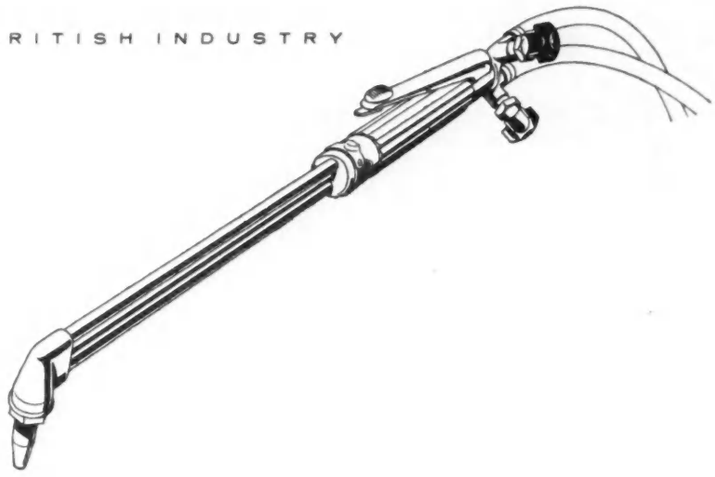

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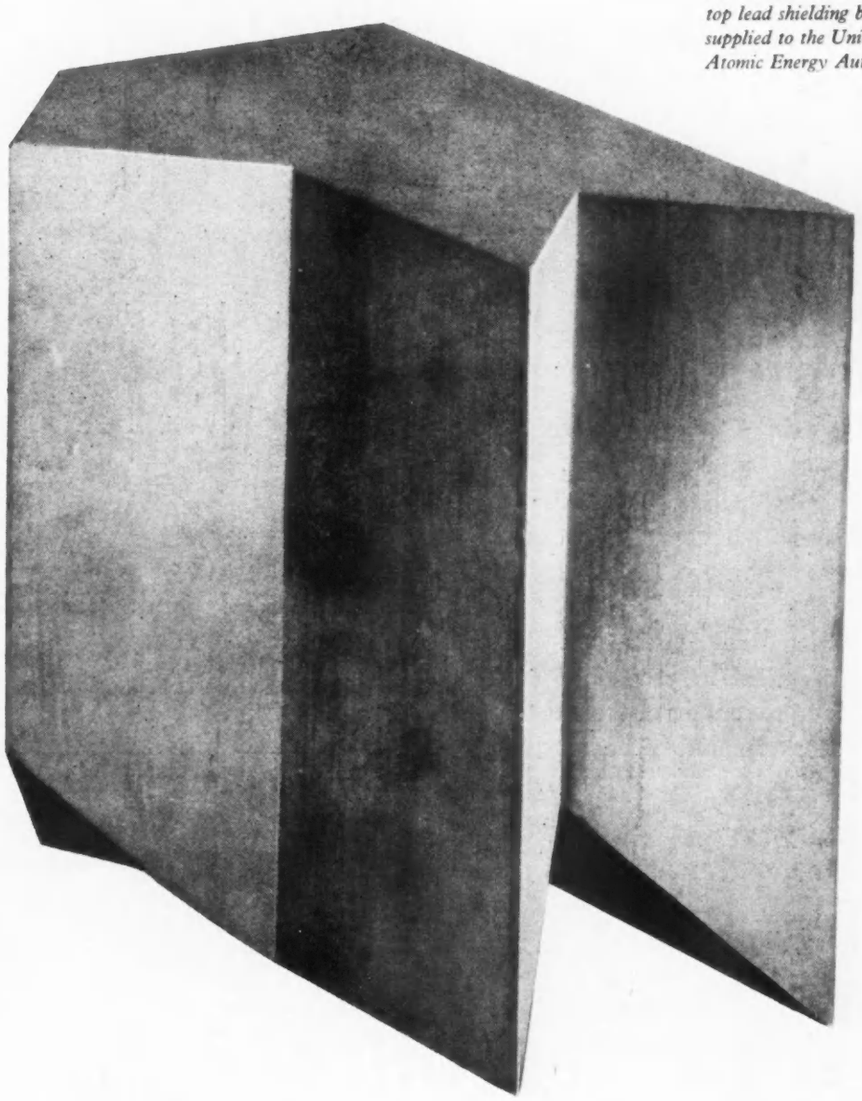

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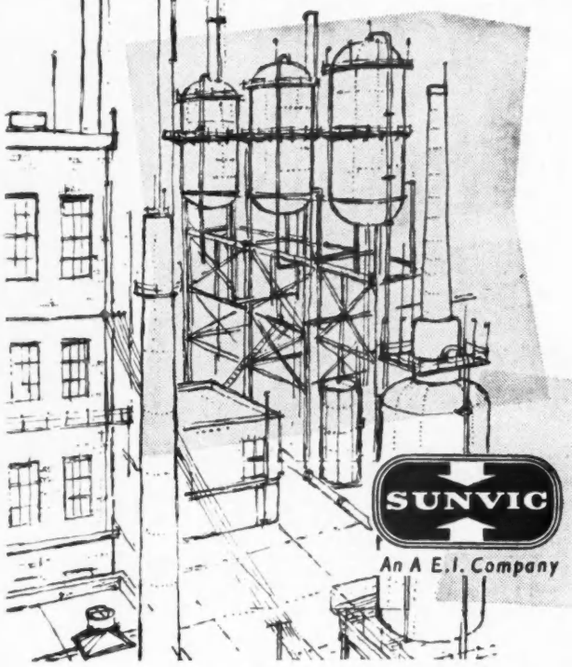

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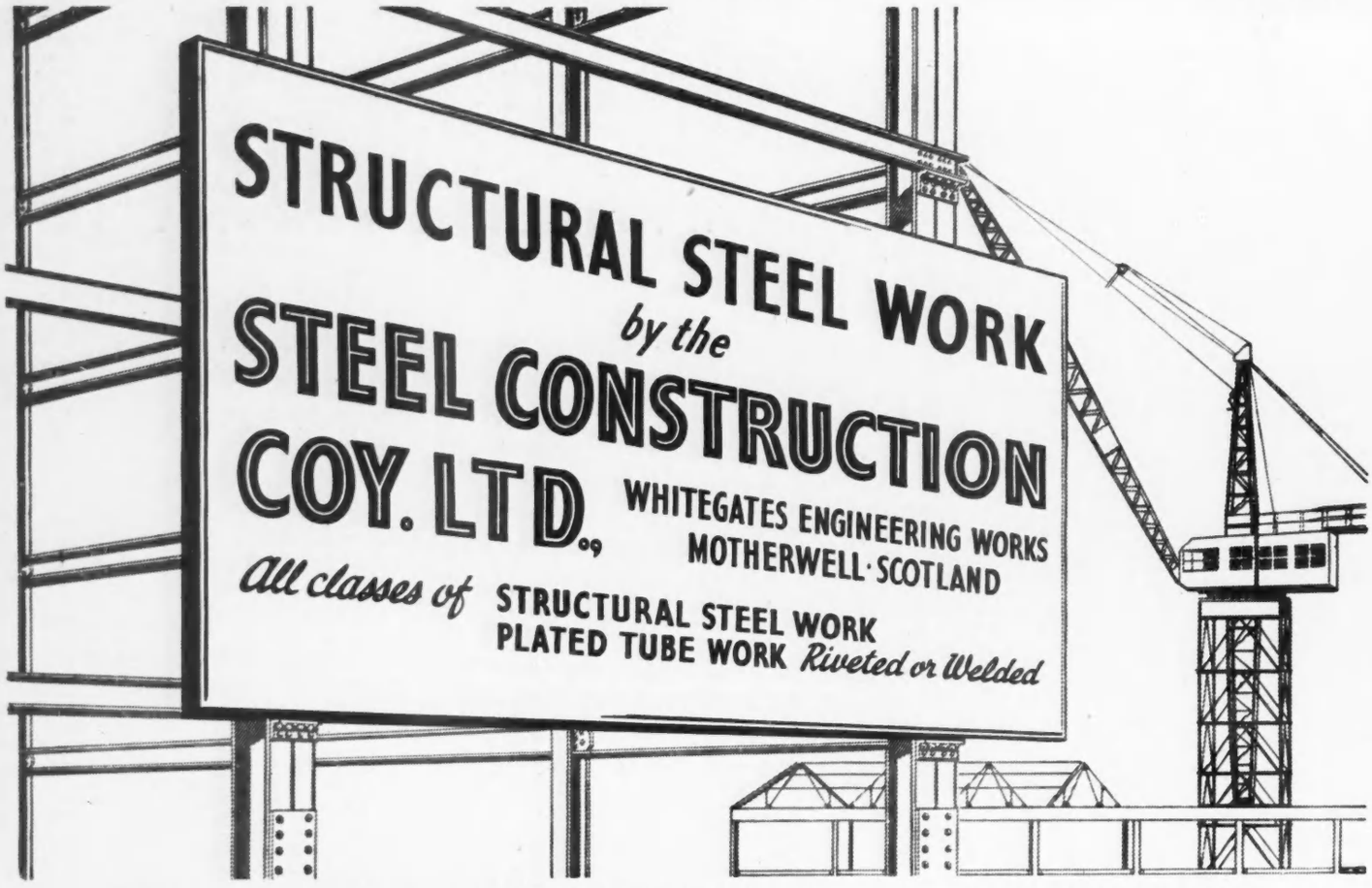

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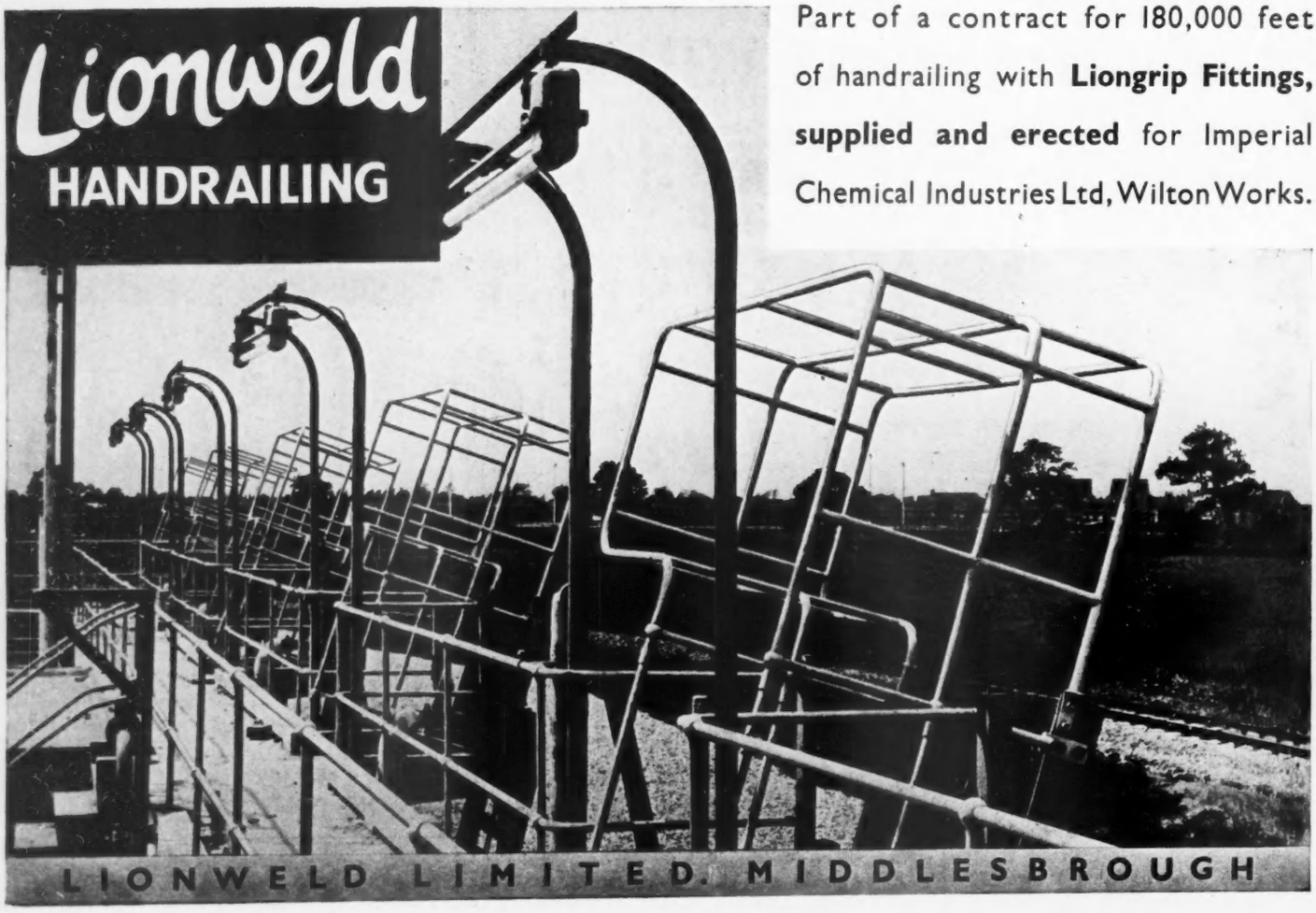

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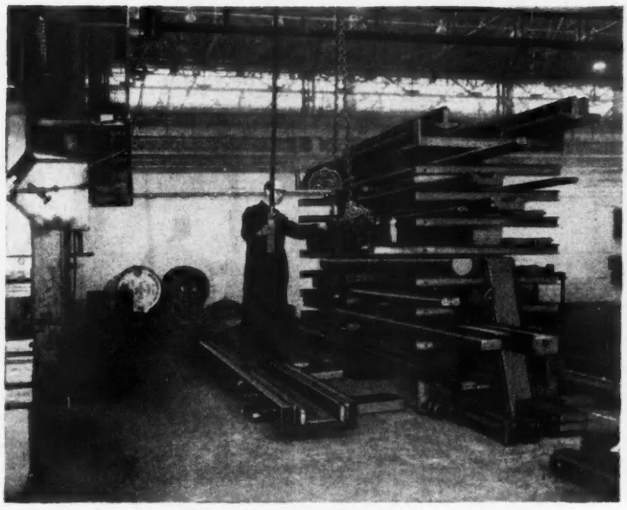

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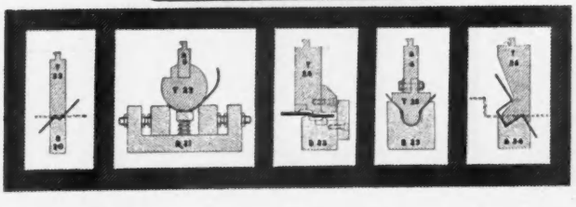

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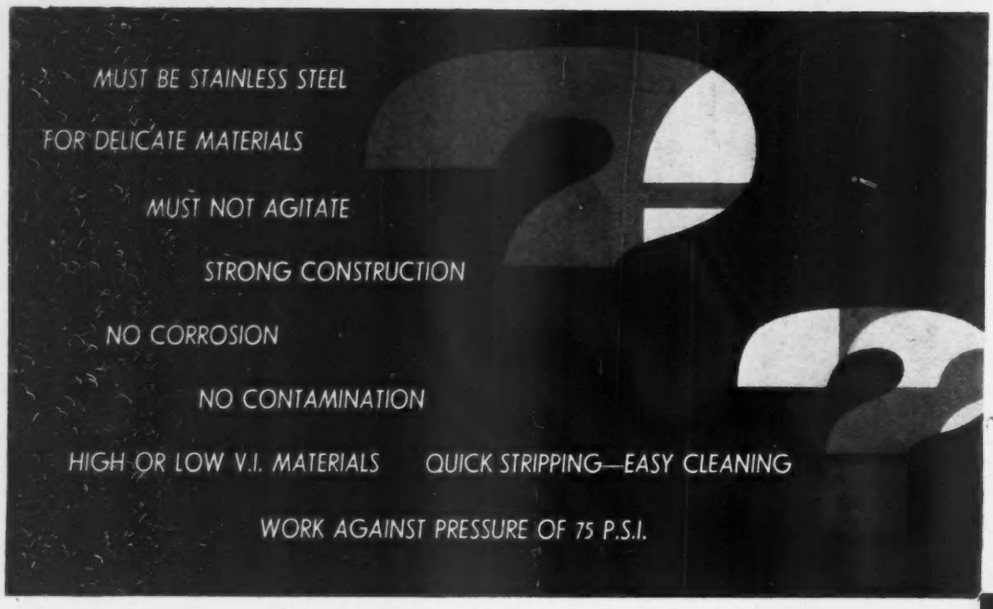

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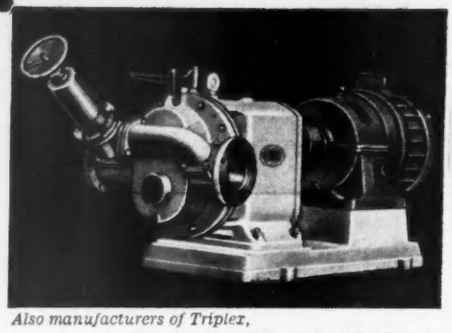

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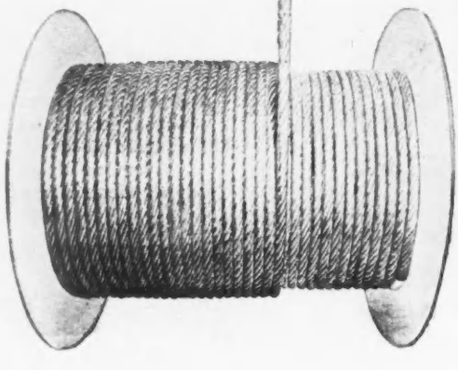

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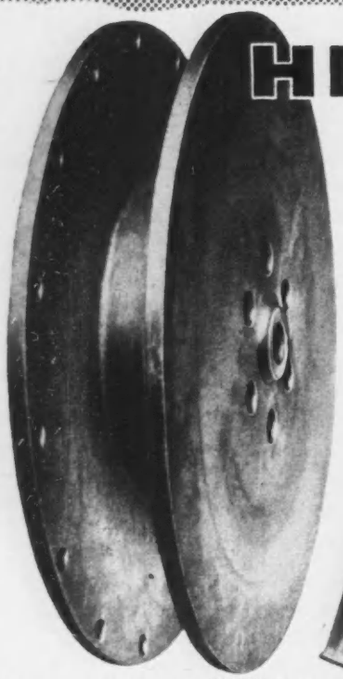

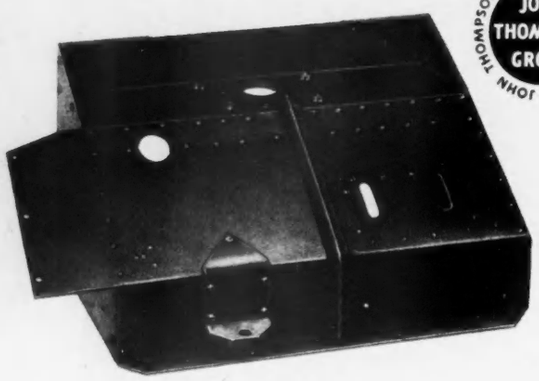

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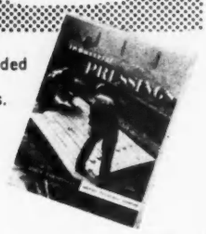

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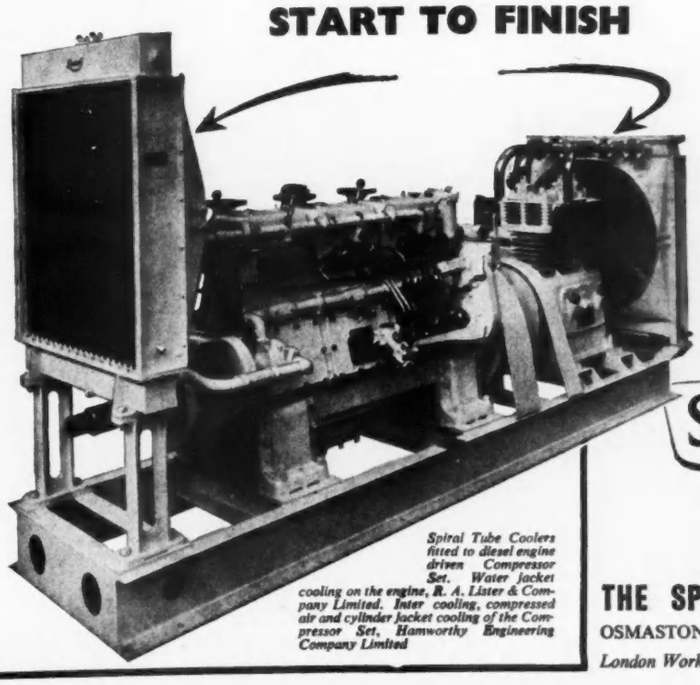

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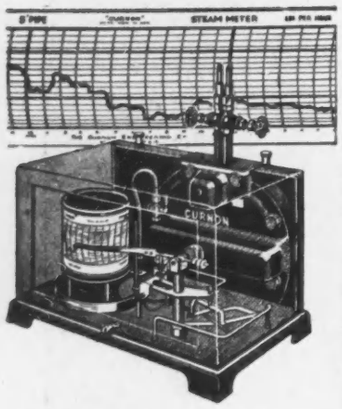

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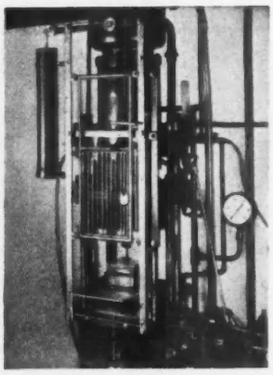

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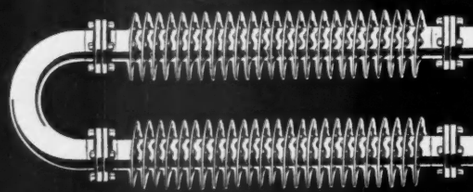

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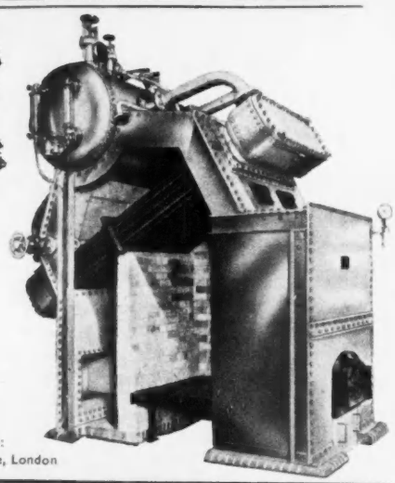

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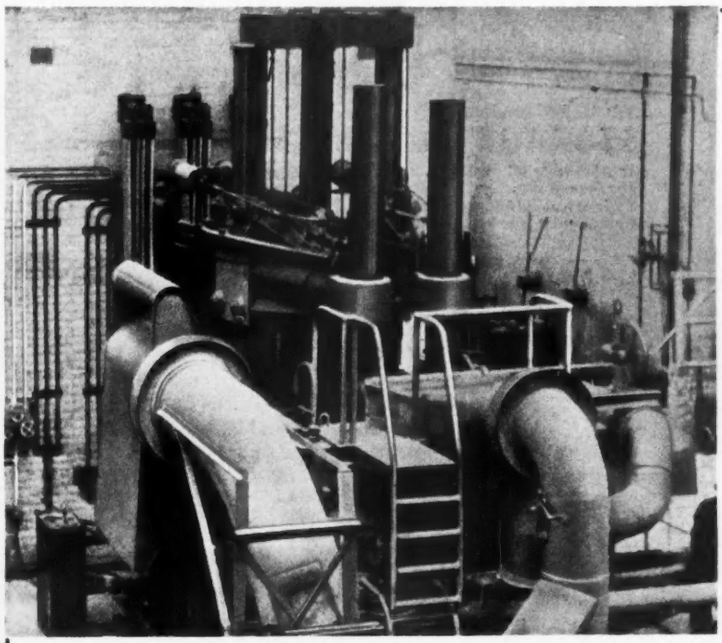

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★ ★ ★ ★ ★ ★ ★

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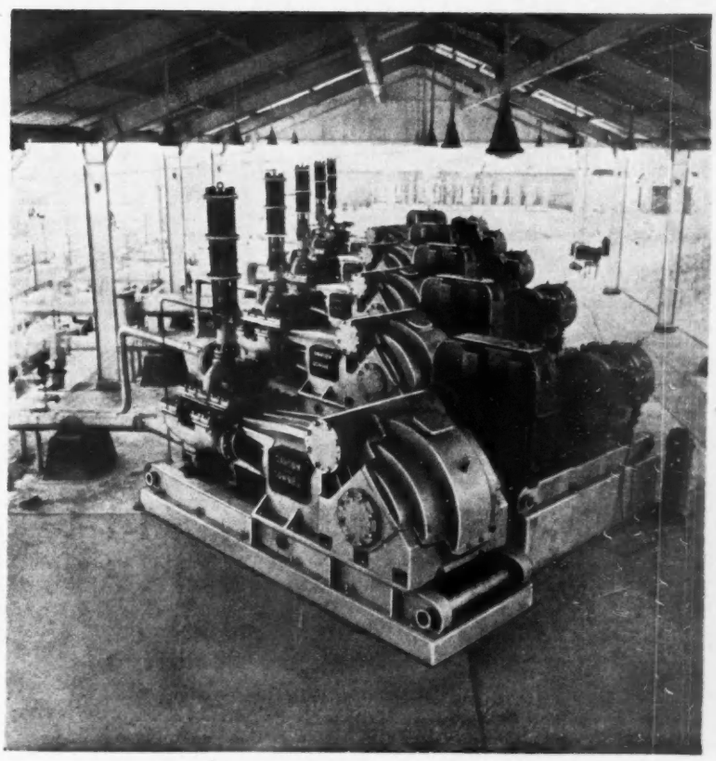


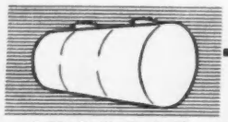
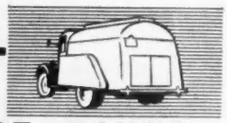
Dawson & Downie Ltd

ELGIN WORKS CLYDEBANK

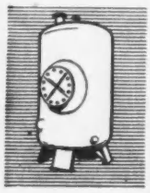
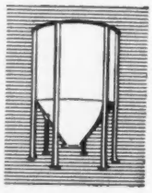
Telephone: Clydebank 2271/2/3 *Telegrams:* "PUMPS" CLYDEBANK

MAKERS OF
GEARBOXES
FOR 40 YEARS

ALBION ENGINEERING CO. LTD.
SAMPSON ROAD NORTH, BIRMINGHAM, 11
Telephone: Birmingham Victoria 4064


M.S.L
Electrically Welded


STORAGE & TRANSPORT TANKS
As supplied to all Ministries, Principal Oil Companies & Petrol Pump Manufacturers
For every storage and transport purpose. Steel Horizontal Tanks, Cylindrical Underground Tanks, Fuel Oil Tanks, Road Wagon Tanks, Rectangular Tanks, Air Receivers, Vats, Hoppers, etc.
When ordering specify M.S.L.

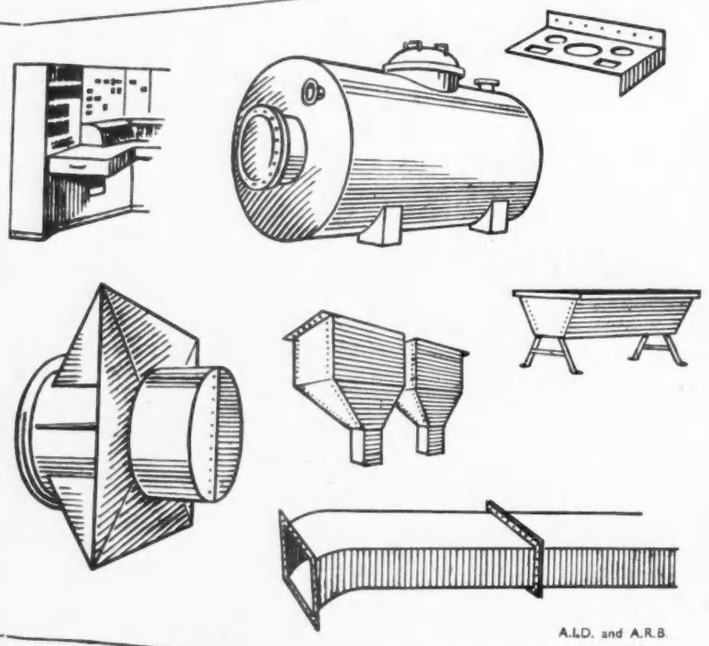

25 Years experience in Fabricated Arc-Welding Construction

Write for full particulars to :—
METAL STRUCTURES, LTD.
Angel Factory Colony, Angel Rd., Edmonton, N.18
Phone: Edmonton 6601/2/3 Grams: Metatru, Southtot, London.

ABBOTT & CO.
(NEWARK) LTD.
Newark Boiler Works
NEWARK : NOTTS
Telegrams: ABBOT NEWARK 34
Telephone: NEWARK 34
BOILERS and AIR RECEIVERS
See Display Advertisement August 29

Waste Heat Recovery Plant
Specialists in the design and construction of Steam-Raising Plant utilising waste gases, in the Gas, Chemical, and Ceramic Industries; also Iron, Steel and Non-Ferrous Metal Industries; Heat Recovery from internal combustion engines and similar prime movers in Land and Marine Installations. A direct method of increasing thermal efficiency and saving fuel.
Consult the Specialist in Waste Heat Recovery.
SPENCER-BONECOURT-CLARKSON LTD. 28 Easton St., London, W.C.1. *Tel: Terminus 7466*

EVERYTHING IN SHEET METAL WORK
GENERAL ENGINEERING

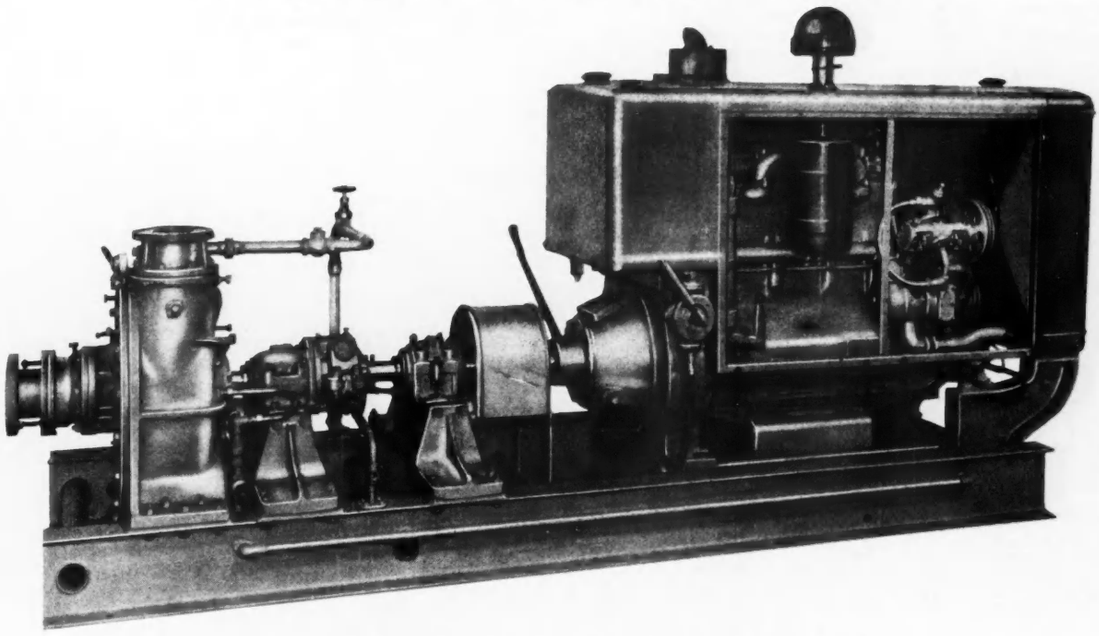
Consult
V. W. CO., LTD.
FOR FABRICATION and GENERAL ENGINEERING
General Sheet Metal Work, Metal Pressing and Stamping, Duct Work and Ventilating Plants, Tanks Cylinders Turning Milling etc. PLATING, Chrome, Nickel, Cadmium etc.



A.I.D. and A.R.B. approved

V. W. CO., LTD.
Radspray Works, High Street, Stratford, London, E.15 *Tel: MARyland 6761 (6 lines)*
Also at: **EASTERN INDUSTRIAL ESTATE, HARLOW, ESSEX** *Tel: 24721*

GRAVEL PUMPS



4½/5" Centrifugal Sand and Gravel Pump with Diesel Engine Drive.

EASTON & JOHNSON LTD. · TAUNTON, ENGLAND

TELEPHONE 3146 GRAMS: EASTWALD, TAUNTON

THE 'BRADFORD' POWER CYLINDER

More power to your elbow with Bradford air or hydraulic power cylinders

Bradford Air Cylinders. In standard sizes from 2" to 20" bore, with hand or remote control. All-steel Hydraulic Cylinders. Standard sizes from 1½" to 12" honed bores, to work at pressures from 200 lbs. to 1,500 lbs per sq. in. with hydraulic fluid, oil or water. Supplied as required with bracket, clevis, trunnion or end cover mountings.

Bradford Air or Hydraulic Cylinders can also be made to customers' specifications with any length of stroke.

UNITED STATES METALLIC PACKING CO. LTD.

U.S.M.P

SOHO WORKS, BRADFORD 8, YORKSHIRE

Telegrams: "Metallic", Bradford
Telephone: Bradford 41284-5

Branch Offices: London, Liverpool, Glasgow, Manchester Newcastle, Cardiff, Southampton, Hull, Swansea and Bristol.

CLASSIFIED ADVERTISEMENTS

AGENCIES · DIRECTORS · PARTNERSHIPS · SITUATIONS VACANT · EDUCATIONAL PATENTS · BUSINESS OPPORTUNITIES · MISCELLANEOUS · PUBLIC APPOINTMENTS BUSINESSES and PREMISES · TENDERS

Lineage Rate. 4/- per line of approximately 6 words. Minimum 16/-.

Inch Rate. 48/- per single column inch and *pro rata*. 12 lines to 1 inch.

There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £25 10s. ½-page £48. Full page £90.

AUCTION SALES · FOR HIRE · MACHINERY, etc., WANTED · SITUATIONS WANTED DRAWING AND DESIGN SERVICES · FOR SALE · SUB-CONTRACTING

Lineage Rate. 3/6 per line of approximately 6 words. Minimum 14/-.

Inch Rate. 42/- per single column inch and *pro rata*. 12 lines to 1 inch.

There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £22. ½-page £41 10s. Full page £78.

Series Discounts. For advertisements 1 inch and upwards. 6 insertions 5%. 13 insertions 10%. 26 insertions 15%.

Run-on and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Use of Box Number. 2/- which includes forwarding of replies.

Copy Dates. "Run-on" and "Semi-displayed" advertisements by noon Tuesday for publication on Friday same week. "Displayed" and "Illustrated" advertisements by noon Friday for publication on following Friday. All advertisements three days earlier if proofs are required.

***Advertisements for publication should be addressed to:*—Classified Advertisement Dept., "The Engineer", 28 Essex Street, Strand, London, W.C.2.**

Urgent advertisements may be telephoned to CENtral 6565.

PUBLIC APPOINTMENTS

UNIVERSITY OF AUCKLAND

NEW ZEALAND

LECTURESHIP OR SENIOR LECTURESHIP IN CIVIL ENGINEERING

Applications are invited for the above-mentioned post. Candidates should be University graduates in Civil Engineering and have had some professional experience. A professional qualification in land surveying and a specialised knowledge of Public Health Engineering would be advantageous.

The appointment will be made either at the grade of Lecturer or Senior Lecturer, depending upon the qualifications of the successful applicant. The salary scale for a Senior Lecturer is £1315–£1615 per annum, rising by three annual increments ; and for a Lecturer is £1025–£1275 per annum, by three annual increments. An allowance is made towards travelling expenses.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36, Gordon Square, London, W.C.1.

The closing date for the receipt of applications, in New Zealand and London, is 31st October, 1958. E8562

UNIVERSITY OF LONDON KING'S COLLEGE

DEPARTMENT OF CIVIL ENGINEERING

LECTURER

Applications are invited for the post of LECTURER IN CIVIL ENGINEERING.

Applicants should have an Honours Degree and professional experience. Special interest in concrete and reinforced concrete will be an advantage. Salary on the scale £900 by £50 per annum to £1350, and then by £75 per annum to £1650, plus £60 per annum London Allowance, with starting point according to qualifications and experience. Family allowances and F.S.S.U. benefits will be payable.

Conditions of appointment and application forms may be obtained from the Registrar, King's College, London, Strand, W.C.2. Completed forms must reach him by September 30th, 1958. E8532

WOOLWICH POLYTECHNIC, LONDON, S.E.18.

CIVIL AND MECHANICAL ENGINEERING DEPARTMENT

SENIOR LECTURER

Applications invited for a SENIOR LECTURER in Civil and Mechanical Engineering Department. Applicants should have a good Degree, together with industrial experience in mechanical engineering, and be able to take Final Year Lectures for B.Sc. (Eng.) Degree and for Diploma in Technology. Also to take some responsibility within the Department.

Salary scale : £1350–£50–£1550, plus London Allowance of £36 to £48.

Particulars and application form from Clerk to Governors, to be returned by 27th September, 1958. E8527

CENTRAL ELECTRICITY GENERATING BOARD

SOUTH EASTERN DIVISION

POWER STATION SUPERINTENDENT

Applications are invited for the post of POWER STATION SUPERINTENDENT at Northfleet Power Station which will commission in 1959 and is designed for an ultimate capacity of 720MW. The salary is in accordance with N.J.M. Scale 5, Class E, £2300–£2500 per annum. The Superintendent will take up his duties in 1958.

Applicants should submit details in the form they judge will be of the greatest assistance in selecting a Short List for interview.—Applications should be addressed to the Establishments Officer, Central Electricity House, Lower Ham Road, Kingston-upon-Thames, so as to arrive not later than 22nd September, 1958. E8544

PUBLIC APPOINTMENTS

WOOLWICH POLYTECHNIC, LONDON, S.E.18.

SENIOR LECTURER

Applications invited for SENIOR LECTURER IN ELECTRICAL ENGINEERING. Should have high academic qualifications and industrial experience and an interest in power and machines ; opportunities for research.

Salary scale : £1350–£50–£1550, plus London Allowance of £36 to £48.

Particulars and application form from Clerk to Governors, to be returned by 27th September. E8528

LONDONDERRY AND GRANSHA HOSPITAL

(A HOSPITAL FOR NERVOUS AND MENTAL DISEASES)

SUPERINTENDENT ENGINEER

Salary £790 by £25 (3) by £30 (2)–£925 per annum.

Applicants must have served a recognised apprenticeship or have otherwise acquired suitable practical training and, should hold a recognised qualification of technical character, such as Extra 1st, 1st Class Certificate of Competency in Marine Engineering or equivalent Naval Certificate : City and Guilds 1st Class Certificate in Plant Engineering.

Applicants should have wide and varied experience of installation, operating, maintaining and recording of steam raising, mechanical and electrical plant and services. A working knowledge of sanitation codes, water supply systems and building maintenance is required, and the ability to control artisan staff is essential.

A suitable house will shortly be available.

Copy of duties and application form may be obtained from Secretary, Londonderry and Gransha Hospital, Strand Road, Londonderry, to whom completed forms should be returned so as to be received not later than October 3rd.

Preference will be given to candidates who served in H.M. Forces.

Canvassing disqualifies. E8548

NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD

SENIOR ASSISTANT ENGINEER (SYSTEM CONTROL)

Applications are invited for the above post. Duties will be to assist Senior Operation Engineer at the Board's Central Control Room, Pitlochry. In addition to supervision of day-to-day operation of hydro and thermal plant, the high-voltage transmission system and bulk energy interchanges, the successful candidate will require to take part in planning arrangements for the most economical operation of generating stations and reservoirs, the relationship of hydro to thermal generation and the application of methods leading to the most efficient operation.

Salary commencing at a point within the range £1435–£1630 (N.J.B. Schedule B, Class AX/CX, Grade 2), depending on experience and qualifications. Superannuation scheme.

Application forms obtainable from the Secretary, 16, Rothesay Terrace, Edinburgh, 3, should be returned within 21 days from the publication of this notice. E8556

EAST ANGLIAN REGIONAL HOSPITAL BOARD

ASSISTANT ENGINEER (MECHANICAL)

ASSISTANT ENGINEER (MECHANICAL)—Candidates should be A.M.I.H.V.E. or Graduate Members of I.H.V.E. or equivalent. Experience in design and installation of heating, ventilating, steam boiler plant and services, &c., as applicable to hospitals desirable but not essential. Salary £700–£1015—additional increments within scale based on experience and age may be granted.

Applications stating age, qualifications, experience and details of present position (salary, &c.) with names of three referees to Secretary of Board, 117, Chesterton Road, Cambridge, by 30th September, 1958. E8508

PUBLIC APPOINTMENTS

CENTRAL ELECTRICITY GENERATING BOARD

SOUTHERN PROJECT GROUP

BRADWELL NUCLEAR POWER STATION

ASSISTANT SITE ELECTRICAL ENGINEER

Applications are invited for the appointment of ASSISTANT ELECTRICAL ENGINEER at Bradwell (Essex) Nuclear Power Station now under construction to assist the Senior Electrical Engineer in the inspection of the installation and the testing of electrical engineering plant in connection with both the conventional and nuclear plant.

Applicants should have qualifications up to H.N.C. or equivalent standard or an Engineering Degree. They should have some works experience or apprenticeship training, and previous experience on a Power Station or similar construction site would be an advantage.

This is a permanent appointment and the successful candidate would be expected to live in the vicinity of the site for the duration of the constructional work which will be approximately a two-year period. Opportunities will be available for transfer to future Power Station sites and to the Design Teams associated with these stations.

The salary for the appointment will be within Grade 5 of the N.J.B. Agreement, Schedule "C," i.e. £1055–£1265 per annum.

Applications stating age, qualifications, experience, present position and salary should be forwarded to The Administrative Officer, Central Electricity Generating Board, Southern Project Group, Squires Lane, Finchley, N.3, to arrive not later than 20th September, 1958. Envelopes should be marked "Confidential—Reference S/58/9."

T. YULE,
E8535 Chief Project Engineer.

CENTRAL ELECTRICITY GENERATING BOARD

RESEARCH LABORATORIES AT LEATHERHEAD, SURREY

ASSISTANT ENGINEERS

Applications are invited for the appointment of ASSISTANT ENGINEERS, to work in the Research Laboratories at Leatherhead, Surrey.

The selected candidates will be required to work on problems associated with conventional and nuclear power stations. Present investigations concern heat transfer in nuclear fuel elements and heat exchangers, electrostatic precipitators, cooling towers and boiler feed pumps.

Candidates for senior vacancies should have an Honours Degree with previous research experience ; for other vacancies a Pass Degree or H.N.C. with appropriate experience would be acceptable, but importance is attached to ability to apply fundamental knowledge.

The salary for these appointments will be on a scale within the range £550–£1510 per annum, according to duties and responsibilities of the post.

Application forms from I. G. Ellis, Personnel Officer, Central Electricity Generating Board, 24–30, Holborn, London, E.C.1, to be returned by 30th September, 1958. Envelopes should be marked "Confidential—Ref. ENR/262." E8523

ARCHWAY GROUP HOSPITAL MANAGEMENT COMMITTEE

WHITTINGTON HOSPITAL, N.19

ASSISTANT ENGINEER

ASSISTANT ENGINEER required at Whittington Hospital, N.19. Applicants over 25 years of age preferred who should have completed practical training in mechanical engineering. Ordinary National Certificate for Mechanical Engineering or equivalent an advantage. Salary scale £525–£645 per annum plus £30 London Weighting at 26 or over. Successful candidate will be required to reside within reasonable distance of hospital. Department may be visited by direct appointment with Hospital Secretary, ARC 3070 Ext. 354.—Application forms obtainable from and returnable to Group Secretary (Dept. P10), 46, Cholmeley Park, N.6 within ten days. E8545

PUBLIC APPOINTMENTS

BRITISH SHIPBUILDING RESEARCH ASSOCIATION

NAVAL ARCHITECTURE SECTION

The British Shipbuilding Research Association has vacancies in its Naval Architecture Section for persons with ability to initiate, lead and execute research. For these posts applicants should have an honours degree in naval architecture. The ceiling of salary is £1600 per annum and the commencing salary will depend upon age and qualifications. There are opportunities of promotion above this ceiling to a higher grade.

In addition to the investigations which the research staff themselves conduct, including work on board ships, they are also engaged upon progressing a programme of researches carried out under contract at outside laboratories, Government research establishments, Universities, &c. Members of the staff also deal with the technical secretarial work of the Association's system of research committees. All positions carry superannuation.

Applications with full particulars of education, apprenticeship, practical training and research experience should be addressed to B.S.R.A., 5, Chesterfield Gardens, Curzon Street, London, W.1. E8568

CENTRAL ELECTRICITY GENERATING BOARD

SOUTHERN PROJECT GROUP

BRADWELL AND BERKELEY NUCLEAR POWER STATIONS

SITE ELECTRICAL ENGINEERS

Applications are invited for the appointments o SENIOR ELECTRICAL ENGINEERS at Bradwell (Essex) and Berkeley (Gloucestershire) Nuclear Power Stations now under construction.

The successful candidates will be responsible to the Resident Engineers on the site for the general supervision of all electrical engineering work associated with the construction of the power station. This will involve the inspection of the installation and the testing of all electrical plant in connection with both the conventional and nuclear plant.

Candidates should have experience in the supervision of construction of major electrical engineering works and in the installation of conventional power station plant ; experience and knowledge of control circuit techniques and instrumentation would be an advantage. Applicants should have a technical education at least up to H.N.C. standard or an Engineering Degree. They should preferably be corporate members of the Institution of Electrical Engineers.

These are permanent appointments and the successful candidates would be expected to live in the vicinity of the site to which they are allocated for the duration of the constructional work which will be approximately a two-year period. Opportunities will be available for transfer to future Power Station sites and to the Design Teams associated with these stations.

The salaries for these appointments will be within Grade 2 of the N.J.B. Agreement, Schedule "C," i.e. £1490–£1840 p.a., according to qualifications and experience.

Applications stating age, qualifications, experience, present position and salary should be forwarded to The Administrative Officer, Central Electricity Generating Board, Southern Project Group, Squires Lane, Finchley, N.3, to arrive not later than 20th September, 1958. Envelopes should be marked "Confidential—Reference S/58/10."

T. YULE,
E8536 Chief Project Engineer.

KENT COUNTY COUNCIL

HEATING ENGINEER

HEATING ENGINEER required with wide design and operating experience and capable of handling fuel economy problems for new and existing installations and promoting efficient operation of plant.

Salary within scale £845–£1025 a year. N.J.C. conditions of service.—Details and application forms from County Architect, Springfield, Maidstone. Closing date 3rd October, 1958. E8542

PUBLIC APPOINTMENTS

CENTRAL ELECTRICITY GENERATING BOARD

NUCLEAR PLANT DESIGN BRANCH

GENERATION DESIGN AND CONSTRUCTION DEPARTMENT

The Generating Board intends to strengthen considerably the team of Engineers and Scientists which guides the design of the nuclear sections of its new power stations. This Branch works in close association with the Atomic Energy Authority and Industry in drawing up specifications and following through the design work, tender assessment, and final acceptance of proposals. The work is concerned with the large stations now being built and with the engineering of future plants. It is based at the Board's Headquarters, Bankside House, London, S.E.1, but involves frequent visits to the Atomic Energy Authority's establishments, to plants under construction and to contractors' works and design offices.

Senior posts are available for :

A : 1. MECHANICAL DESIGN ENGINEER—responsible for the mechanical design of the whole reactor and boiler unit and for the guidance of work under A 2, 3, 4 and 5 below.
2. REACTOR CORE ENGINEER—the design of the reactor core, including the fuel element.
3. MECHANISMS ENGINEER—the design of equipment for replacing the uranium fuel in the reactor, the control rod actuators and general mechanical handling of fuel, including radioactive fuel.
4. PRESSURE CIRCUIT ENGINEER—the design of pressure vessels, boilers, ductwork and coolant circulators.
5. REACTOR MATERIALS ENGINEER—selection and supervising the use of materials for the whole reactor unit, having regard to all conditions of operation.

B : LAYOUT ENGINEER—the layout of the nuclear part of the plant ; accommodation design of the reactor buildings ; consideration of radiation levels in workrooms and about the site.

C : PERFORMANCE ENGINEER—estimation of plant performance, nuclear, thermodynamics and heat transfer calculations.

It is expected that these posts will be filled by men of considerable and appropriate experience, based on a sound technical training which has led to a good University Degree and/or Corporate Membership of a Senior Institution.

A : 1–4 will mainly interest Mechanical Engineers.
A : 5 is suitable for Metallurgists with an engineering outlook.
B : Is suitable for a Civil Engineer with an interest in layout work. He must be prepared to consider the influence of radiation from the plant upon this, and although assistance will be given in the more technical calculations, he must be prepared to direct them.
C : Experience is desirable of power plant performance, estimation and sufficient mathematical interest to handle at least some of the nuclear calculations.

Salaries will be within the following scales :—

A : 1, £2560–£2760 p.a.
A : 2–5, £1960–£2160 p.a.
B : £1960–£2160 p.a.
C : £2160–£2360 p.a.

Applications are also invited from well-qualified, but less experienced, men for posts within Sections A 2–5, B and C above, and within the Instrumentation and Control Section, which is concerned with the design and overall control systems for the complete plant and the specification of the required instrumentation. Specialist training in nuclear techniques will be given where necessary.

Salaries will be on a scale within the range £1105–£2005 p.a., according to duties and responsibilities of the posts.

Applications, stating age, qualifications, experience, present position and salary, should be forwarded to I. G. Ellis, Personnel Officer, 24–30, Holborn, London, E.C.1, by 27th September. Envelopes should be marked "Confidential," quoting reference ENR/265. E8557

BRITISH RAILWAYS RESEARCH DEPARTMENT

SENIOR TECHNICAL ASSISTANT

Vacancy at Derby for SENIOR TECHNICAL ASSISTANT in group engaged on research on marshalling yards, hydraulic buffers and drawgear, and on shocks sustained by goods and vehicles in transit. The candidates should have a good engineering training with professional or academic qualifications. A knowledge of experimental work valuable.

Salary range : £833 to £985 per annum.
Free and reduced rate travelling facilities.
Medical examination.
Applications, stating age, qualifications, &c., to :
DIRECTOR OF RESEARCH,
British Transport Commission,
(British Railways Division),
222, Marylebone Road,
London, N.W.1. E8519

LONDON TRANSPORT

BRIDGES AND STRUCTURES SECTION

ENGINEERING ASSISTANTS

London Transport requires ENGINEERING ASSISTANTS for Bridges and Structures Section, for production of finished designs in steel or reinforced concrete without close supervision. Preference given to candidates possessing qualification in Civil or Structural Engineering or whose studies have reached an advanced stage.

Salary range £814 per annum to £979 per annum. Medical examination ; free travel ; contributory superannuation.

Applications, giving details of age, qualifications and experience, within 7 days, to Staff and Welfare Officer (F/EV703), London Transport, 55, Broadway, S.W.1. E8578

PUBLIC APPOINTMENTS

SOUTH OF SCOTLAND ELECTRICITY BOARD

CHIEF ENGINEER'S DEPARTMENT

PRINCIPAL ASSISTANT ENGINEER (CIVIL)

Applications are invited for the following superannuable appointment in the Generation/Construction Section of the Chief Engineer's Department at Board Headquarters, Glasgow.

PRINCIPAL ASSISTANT ENGINEER (CIVIL) (Reference No. E34/58).

Preference will be given to applicants who hold a degree in civil engineering, are Corporate Members of the Institution of Civil Engineers or possess equivalent qualifications. They should have had experience in the design and construction of foundations and buildings for large power stations, river and sea works, large culverts, road works and other ancillary works. Experience of the preparation of specifications, estimates and bills of quantities and a knowledge of hydraulics will be an advantage.

Salary : £1900–£2100 per annum in accordance with Scale 6 of the Managerial and Higher Executive salary scales.

Apply (quoting appropriate reference number) on standard form AE.6 available from the Secretary, P.O. Box 173, 351, Sauchiehall Street, Glasgow, C.2, not later than 30th September, 1958. E8513

NEW SOUTH WALES, AUSTRALIA

DEPARTMENT OF MAIN ROADS

CIVIL ENGINEERS

Applications are invited from Graduates (or Undergraduates in their final year) in Civil Engineering of a recognised British or Irish University for appointment to the staff of the Department of Main Roads, New South Wales, the State Road Authority for construction of roads and bridges.

On appointment, applicants may be engaged at the Department's Head Office, Sydney, on the design of reinforced concrete and steel bridges, or on main road construction and maintenance either in the Metropolitan Area or the country.

Commencing salary, according to qualifications and experience, will be within the range £A1185 to £A1410 per annum, with annual progression, subject to technical competence, to £A2095 per annum. Appointees will be eligible to contribute to the State Superannuation Fund after six months.

Appointee's full fare from England to Australia will be met by the Department subject to a three years' service guarantee bond being completed. Appointment will be subject to passing a medical examination and preference will be given to applicants not more than 30 years of age.

Applications should be made on forms obtainable from the Agent General for New South Wales 56, Strand, London, W.C.2. E8551

PUBLIC APPOINTMENTS

REACTOR ENGINEERS

HEALTH AND SAFETY BRANCH
THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY
require

ENGINEERS

for their

HEALTH AND SAFETY BRANCH
(Reactor Division)
at
INDUSTRIAL GROUP HEADQUARTERS
RISLEY, WARRINGTON, LANCASHIRE

to join sections responsible for the critical analysis of reactor control systems on all types of experimental and power reactors, with particular emphasis on fast and advanced gas-cooled reactors.

One section will be concerned with the technical calculations arising from the study of reactor systems, and for these posts a good academic standard is required. While direct experience of nuclear work is not essential, applicants should have experience in industry of technical calculations, particularly relating to heat transfer, fluid flow and the mechanics of solids.

A second section will deal with the engineering evaluation of reactor systems, with special emphasis on reactor control. The preparation of related Codes of Practice and the development of standards of operation and design applicable to reactor safety will be included. A broad rather than specialised experience in the fields of mechanical, process or chemical engineering is required for these appointments, and some knowledge of instrumentation and control would be an advantage.

Corporate membership of a senior engineering institution, or equivalent, is essential for all posts.

Where necessary, successful candidates will be given training at the Harwell Reactor School and operating experience on Authority reactors.

Salaries will be assessed within the scale
£815 (at age 25) to £2080,
according to qualifications and experience.
Contributory Pension Scheme.

Housing or assistance towards legal expenses on house purchase may be available.

Send postcard for application form, quoting reference 2511, to Recruitment Officer, Industrial Group Headquarters, Risley.

CLOSING DATE:
15TH SEPTEMBER, 1958. E8525

A.E.R.E. HARWELL | OPERATIONS ENGINEERS

There are vacancies offering excellent training to professionally qualified engineers in the operation of high flux experimental nuclear reactors. There are also vacancies for men with good experience in watch-keeping of large machinery. All posts will at first involve shift work.

Salary : £815-£1270 or £1300-£1740 (Engineer III or II)

Send post card for further details and application form to the Group Recruitment Officer (1206/25), U.K.A.E.A., Atomic Energy Research Establishment, Didcot, Berks.

E8530

ENGINEER/TECHNICIAN

required by

THE ATOMIC WEAPONS RESEARCH ESTABLISHMENT, ALDERMASTON, BERKSHIRE.

To assess the engineering requirements necessary to meet a tight production schedule, to integrate the production requirements of several divisions into a co-ordinated programme and to make a quick and reliable forecast of requirements from limited information.

A recognised engineering apprenticeship is required with considerable experience in all aspects of production. For the Engineer : grade membership of one of the Senior Engineering Institutions is essential, and for the Technical grade an O.N.C. or equivalent is the minimum qualification.

SALARY : Engineer II. £1300–£1740 p.a.
Tech. "B" £1270–£1420 p.a.

Contributory Superannuation Scheme. A house or assistance towards legal expenses on house purchase will become available for married officers living beyond daily travelling distance.

Postcards for application forms to the Senior Recruitment Officer at above address. Please quote ref. 1939/25.

E8581

PUBLIC APPOINTMENTS

SHEFFIELD CORPORATION WATERWORKS

APPOINTMENT OF TECHNICAL STAFF

Applications are invited for the following appointment on the permanent staff of the Waterworks General Manager and Engineer (J. Noel Wood, M.I.C.E.). Commencing salary according to qualifications, ability and experience.

SENIOR TECHNICAL ASSISTANT, Special Classes Grade, £750 by £40 to £1030 per annum. Applicants must be University Graduates with at least five years' experience (including the period spent on theoretical training), or have passed Parts I and II of the examination of the Institution of Civil Engineers.

The post is superannuable and successful applicants will be required to pass a medical examination.

Applications, stating age, education and training, qualifications, present and past appointments (with dates and salaries) and quoting the names and addresses of two referees, should be sent to the undersigned not later than the 24th September, 1958.

JOHN HEYS,
Town Clerk.
Town Hall,
Sheffield, 1. E8577

TENDERS

SOUTHAMPTON CORPORATION WATERWORKS

RIVER ITCHEN SUPPLY—CONTRACT NO. 13

PUMPING PLANT

TENDERS are invited from manufacturers of centrifugal pumps for the SUPPLY and ERECTION of TWO SETS of Electrically Driven SUPPLY PUMPS, complete with D.C. Motors and other Equipment. (Approximate duty of each set 4,000,000 gallons per day against 230ft. head.)

Specification and conditions may be obtained from the Waterworks Engineer and Manager, Civic Centre, Southampton. Tenders to Town Clerk, Civic Centre, Southampton, by Monday, 20th October, 1958. E8466

EDUCATIONAL

THE SCHOOL OF ORIENTAL AND AFRICAN STUDIES

UNIVERSITY OF LONDON, W.C.1

MODERN ARABIC

An Intensive Introductory Course will be held from 1 October to 10 December, 1958. Instruction will be given in basic grammar, translation, Press and Radio Arabic, the grammar of Colloquial Arabic, and general Middle Eastern topics. Fee : £40 10s. per head.—Enquiries to the Organiser of Special Courses. E8529 g

UNIVERSITY OF LONDON KING'S COLLEGE

RESEARCH STUDENTSHIPS

University of London King's College offers the following RESEARCH STUDENTSHIPS, made available by Joseph Lucas, Ltd., and tenable in the College for one year with possible renewal for a second year.

(a) One of £800 a year for research into the initiation of explosions in gases, vapours and powder clouds.

(b) One of £500 a year for research into the mixing of powdered materials.

The character of the researches is such as should lead to a Higher Degree. Applicants for (a) should have a good Honours degree in Mechanical or Electrical Engineering or Physics and preferably some research experience.

Applicants for (b) should have a good Honours degree in some branch of Engineering, Physics and Chemistry.

Particulars and application forms from the Registrar, King's College, London, Strand, W.C.2., whom completed forms must reach by October 6th. E8511 g

UNIVERSITY OF LONDON KING'S COLLEGE

RESEARCH STUDENTSHIP

University of London King's College offers a RESEARCH STUDENTSHIP, made available by Usines Emile Henricot, S.A., and tenable in the College for one year with possible renewal for a second year. The value will be £500 a year. The Studentship is for research into various aspects of the mechanical behaviour of ball mills ; the character of the research is such that it should lead to a Higher Degree.—Applicants should have a good Honours degree in some branch of Engineering.—Particulars and application forms from the Registrar, King's College, London, Strand, W.C.2, whom completed forms must reach by October 6th. E8512 g

A.M.I.MECH.E., B.Sc., City and Guilds, &c. Guarantee Postal Courses for all Exams., and Technical Divisions from Elementary to Degree standard. Approximately 95 per cent. successes. 144-page prospectus free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E114 g

Classified Advts. continued on page 124

EDUCATIONAL

UNIVERSITY OF GLASGOW

RANKINE CHAIR OF ENGINEERING

(MECHANICS AND MECHANISM)

The University Court intend to consider an appointment to the Rankine Chair of Engineering (Mechanics and Mechanism) towards the end of 1958. Applications are invited before 30th November, 1958. Further particulars will be supplied on application to the undersigned.

ROBT. T. HUTCHESON,
Secretary of University Court.

E8563 E

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES, NOT ORIGINALS, OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

A GRADUATE METALLURGIST with little or no industrial experience is required for interesting work in the Development Department of an old-established non-ferrous metals company in S.W. Lancs. Candidates should submit in strictest confidence, full details of education and qualifications to BOX No. 16762, C. Vernon and Sons, Ltd., Advertising Agents, 74, Rodney Street, Liverpool, 1.

E8433 A

AGENT with connections with Architects, Engineers and Industrial Undertakings, required to Represent Constructional Steelwork and Platework Engineers.—BOX No. E2085, "The Engineer." A

AMGUEDDFA GENEDLAETHOL CYMRU
NATIONAL MUSEUM OF WALES

Applications are invited for the post of ASSISTANT KEEPER to take charge of and develop a Department of Industry. The appointment will be to Grade I (salary £1200–£1890) and the point of entry will be according to age and experience.

Applicants should be not less than 30 years of age and possess an appropriate university degree or equivalent professional qualification in at least one relevant aspect of science and technology as applied to industry. Museum experience and a knowledge of industry in Wales would be advantages.

F.S.S.U.

Applications must be received by 15th October, 1958. Particulars and application forms from: The Secretary, National Museum of Wales, Cardiff.

E8522 A

AN ELECTRICAL MAINTENANCE FOREMAN is required for a large continuous processing factory in London, E.16. Applicants should have a wide practical experience of H.T. and M.T. switchgear and distribution, installation and maintenance of A.C. and D.C. motors, starters and automatic control systems. Previous supervisory experience essential. The salary offered will be commensurate with the responsibilities involved. Contributory Pension Scheme. Welfare, Sickness and Canteen facilities are offered by the Company.—Applications (which will be treated in strict confidence) should be made to Personnel Dept., BOX No. E8524, "The Engineer." A

A large industrial company in the South of England is engaged on

A PROGRAMME OF EXPANSION

running into several million pounds. The programme not only includes extensions to existing plants, but provides also for increased activity in relatively novel fields. The individual projects vary in character and involve all types of engineering from light precision machine work to heavy process equipment, and include all the planning, layout and procurement associated with the design and erection of large manufacturing units.

To help this programme forward, the Company proposes to engage a few first-class men to strengthen its Engineering Division. Applications are invited from men holding First or Second Class Honours degrees in mechanical or chemical engineering with some years of industrial experience following graduation. In addition to technical competence, the organisation requires men of energy and initiative with good personal qualities. The Company would also be glad to hear from men who are graduating this year, who are free from National Service, and who have served a recognised apprenticeship.

Attractive starting salaries will be paid and those appointed should progress fairly rapidly to an initial salary ceiling of around £1500 per annum. Beyond this there is plenty of scope for progressive remuneration. The Company works a 5-day week in pleasant surroundings, and pension and profit-sharing schemes are in operation. Mortgage facilities can be arranged towards house purchase, and assistance is also available towards removal expenses.—Apply briefly to BOX No. E8521, "The Engineer," quoting Ref. E.I.

A

A YOUNG ENGINEER is required for some development work and the preparation of schemes which involve high-pressure hydraulic equipment. Applicants should have a good general mechanical engineering background and some Drawing-Office experience. Knowledge of hydraulics would be an advantage. Minimum qualification required O.N.C. in mechanical engineering with preferably an H.N.C. —Apply in writing, giving full details of qualifications, experience and salary expected to Secretary, E. P. Barrus, Ltd., 12–16, Brunel Road, Acton, W.3.

E8496 A

A WELL-KNOWN General Engineering Company in the North West of England invites applicants for the position of CHIEF INSPECTOR, to take complete charge of all inspection functions throughout their recently expanded factory. Candidates should be first-class engineers, fully experienced in the control of labour, and must at present hold a similar position. There is ample scope for advancement for the right man. Please reply, stating age, qualifications, experience, salary required and present salary. —BOX No. E8515, "The Engineer." A

ASSISTANT PLANT MANAGER
required
by large Engineering Company, Glasgow, with experience of engineering plant maintenance, machine tools and fuel efficiency problems.—BOX No. E8565, "The Engineer." A

APPLICATIONS ARE INVITED for the following appointment at the CLAYDON, SUFFOLK, Works of THE BRITISH STEEL PILING CO., LTD.

SENIOR DESIGNER DRAUGHTSMAN (Minimum qualifications H.N.C. or equivalent).

Minimum age 28 years. Candidates should be capable of accepting responsibility for complete projects.

THIS APPOINTMENT IS PERMANENT AND PROGRESSIVE IN AN EXPANDING ORGANISATION and the successful candidate will be engaged on interesting work in connection with special crane type structures, hoisting machinery (steam, diesel, electric) and contractors' plant.

Contributory Pension Scheme in operation. Good Canteen facilities. The Works are situated 15 minutes' bus ride from the centre of Ipswich.—Apply in writing, giving full particulars of age, experience, qualifications and salary required, to the Personnel Officer at the above address. E8418 A

APPLICATIONS are invited from ENGINEERS for responsible posts in the following fields:

Machining and Pressworking Processes.
Design and Development of Machine Tools.
Automation of Production and Inspection Processes (a knowledge of work study techniques would be advantageous).
Vibration and Servo-mechanisms.

Excellent opportunities for those with ability and initiative. Candidates should have a degree, Higher National Certificate or equivalent qualification.—Send full details including age, qualifications, experience and present salary in confidence.—BOX No. E8502, "The Engineer." A

BROWN AND POLSON LIMITED
largest manufacturers of Maize Starch and its derivatives in Britain and part of an international organisation in this field, require in this expanding industry

GRADUATES

in Mechanical or Chemical Engineering or Applied Chemistry and other young men with minimum H.N.C. qualifications, at their Manchester Plant.

Age up to 32.

Industrial experience and educational and personal details must be given in applications.

The company's salary scales are good, and modern employee benefits and a Profit Payment Plan are in operation.

Write to Group Personnel Manager,
Brown & Polson Limited,
125/130, Strand,
London, W.C.2.

E8579 A

CHIEF ENGINEER required for modern works in the Midlands, engaged in the production of light alloys in all wrought forms (sheet, strip, extrusions, wire, tube, pressings and forgings). The post is one demanding organising ability in addition to the obvious requirement of a first-class training in mechanical and electrical engineering. The duties cover the complete charge of a large engineering department. This includes a drawing-office handling the design and specification of all machinery and plant and workshops dealing with the manufacture, erection, maintenance and repair of all plant, services and equipment. A knowledge of general heavy engineering is essential, preferably associated with rolling mills and hydraulics. The salary will be in accordance with training and experience, the position being a progressive one offering an excellent opportunity to a man between 35 and 45. Applicants should give chronological details of their training and experience, and state age and salary level expected.—BOX No. E8325, "The Engineer." A

COMPRESSOR DESIGNER required with extensive experience in design and manufacturing problems associated with multi-stage Air Compressors for responsible position in new product section of established medium Engineering Company. Substantial salary commensurate with experience, ability and qualifications.—Write, giving fullest details and age to BOX No. E8517, "The Engineer." A

DESIGN DRAUGHTSMAN with experience of gear and gear unit design, required by the Gear Division of George Angus and Co., Ltd., for interesting design and development work. Good prospects. Previous experience of gear design essential. An application from an older man would be considered. —Applications, with details of salary required, to Personnel Manager, George Angus and Co., Ltd., Oil Seal Division, Coast Road, Wallsend, Northumberland. E8558 A

DESIGNER/DRAUGHTSMEN—preferably experienced in design of jib cranes, &c. The positions offered are due to expansion of the firm's activities; would be permanent, progressive, and would carry salaries commensurate with experience. Pension scheme. Five-day week.—Apply: Chief Draughtsman, Clyde Crane and Engineering Company, Mossend, Bellshill. E8575 A

DRAUGHTSMEN, Senior, wanted for firm in North Staffordshire, with mechanical and steel structural experience. Good wages offered with assistance for housing accommodation. Contributory pension scheme. Apply.—BOX No. E2074, "The Engineer." A

CONTRACTS ENGINEER required in West End of London. A.M.I.Mech.E. or equivalent. Able take responsibility for preparation of large composite tenders and office supervision of resulting contracts. Some electrical knowledge desirable. Experience in the rubber/plastics or associated manufacturing industries an advantage but not essential. Excellent opportunity for right man. Applications, with full details and indication of salary required, will be treated in absolute confidence. Apply.—BOX No. E2082, "The Engineer." A

ELECTRICAL ENGINEERING ASSISTANT required for large process factory in Belfast. The position requires experience in installation and maintenance of H.T. and M.T. switchgear, distribution systems and A.C. motors, starters, automatic control systems, &c. Responsibility will include supervision of the Electrical Section of the Engineering Department, preparation of schemes, estimates and drawings and the supervision of outside contractors, &c. Minimum qualifications: University degree or Graduateship I.E.E., with three years' practical experience in a supervisory position. Salary range: £950–£1150 p.a. according to age and experience, Contributory pension scheme, welfare, sickness and canteen facilities, &c., are offered by the company.—Applications (which will be treated in strict confidence) should be made to BOX No. E8471, "The Engineer." A

HEAD WRIGHTSON & COMPANY LIMITED
NUCLEAR POWER DIVISION

Require additional staff for their Drawing Office at

Yarm-on-Tees.

Two Junior Draughtsmen required with Mechanical Engineering experience.

Four Draughtsmen required with Chemical or General Engineering experience.

First-class working conditions with Staff Pension Scheme, assistance in house purchase.

Applications, stating age, qualifications and experience, to:—

Personnel Manager, Ref. N.P/9, Teesdale Iron Works, Thornaby-on-Tees.

E8553 A

INSTRUMENTATION ENGINEER required, experienced in the design of major electro-pneumatic installations in connection with the Oil Refining and Chemical Industries. This position offers good prospects and a commencing salary up to £1500 per annum. Please reply, giving full details of experience and qualifications.—BOX No. E8554, "The Engineer." A

MECHANICAL ENGINEER: VENEZUELA

TWO MECHANICAL ENGINEERS, age 35 or under, are sought for 100MW steam power station in Venezuela. Qualifications required are:

Higher National Certificate, University Degree or Corporate Membership of Institution of Mechanical Engineers or equal.

At least five years of operating and maintenance experience in a responsible position with steam generating plant of 50MW or higher.

Knowledge of Spanish would be useful. Salary paid in U.S. dollars, will be on a generous scale. Full details should be forwarded by post, quoting Ref. 2409, to: Messrs. Mackness & Shipley, Consulting Engineers, Parliament Mansions, Abbey Orchard Street, London, S.W.1.

E8567 A

METALLURGIST
required
by NORTH BRITISH LOCOMOTIVE COMPANY LIMITED, Springburn, Glasgow, fully qualified, preferably with extensive experience in Heat Treatment of Alloy Steels, Welding problems and Mechanical failures.—Write to Engineering Director, stating age, training, experience, &c.

E8564 A

MUNICIPAL MUTUAL INSURANCE, LTD. has vacancies for ENGINEER SURVEYORS in Birmingham and London. Posts are pensionable and permanent to satisfactory candidates who should have served an apprenticeship and have sound practical and theoretical knowledge. Technical qualifications: First Class Ministry of Transport Certificate. Salary: £735–£1060 per annum.—Apply in own handwriting marking the envelope "Application: Engineer Surveyor" and "Private and Confidential" to the Chief Engineer, 22, Old Queen Street, Westminster, S.W.1. E8573 A

POWER RECTIFIER DESIGN

A large manufacturing firm in the Midlands requires electrical engineers to assist in development and design of high-power rectifier equipments, in a rapidly growing Department handling rectifiers of both mercury arc and semi-conductor types for applications of all kinds. Work offers scope for wide experience and interest, with good salary and prospects. Previous rectifier experience not necessary, but a degree or equivalent, and some practical experience, are desirable. Good residential district with excellent educational facilities and ample housing available.—Apply with full particulars to BOX No. E8526, "The Engineer." A

QUALIFIED ENGINEER required for an appointment in the Head Office of a leading Oil Company. Degree in Engineering or A.M.I.Mech.E., and a minimum of 10 years' experience in industry, preferably sales, essential. Ability to lecture is desirable. Candidates, aged 30–40, should write, quoting Ref. HE 9406 C.—BOX No. E8559, "The Engineer." A

MUNICIPAL MUTUAL INSURANCE, LTD. has a vacancy for a CRANE AND LIFTING GEAR SURVEYOR preferably with Higher National Certificate in London. Post is permanent and pensionable to satisfactory candidate who should have served an apprenticeship and have sound practical and theoretical knowledge of cranes and lifting gear. Salary: £735–£1060 per annum.—Apply in own handwriting marking the envelope "Private and Confidential" to Chief Engineer, Old Queen Street, Westminster, S.W.1. E8574 A

PRODUCTION ENGINEER with specialist knowledge of sheet metal work and engineering appertaining to the Heating and Ventilating, Dust Collecting and Allied Trades, required by South London Works. Applicants must be thoroughly conversant with modern workshop planning and procedure. Experience in estimating from drawings essential. A progressive position with fine opportunities for advancement for hard working and efficient engineer. Apply, stating full details of age, education, experience and salary required.—BOX No. E2084, "The Engineer." A

RESIDENT ENGINEER

Sound knowledge of maintenance and operation of Engineering Services of a Residential College, including mechanical and electrical, must possess approved qualifications. Salary within the scale of £700 to £850 with house, light and heat, according to qualifications and experience.—Write for details of appointment and application form to George Sturgess, Estate Agent, Co-operative Union, Ltd., Co-operative College, Stanford Hall, Loughborough, endorsing envelope "Resident Engineer." E8444 A

RUSTON AND HORNSBY, LTD.
have vacancies in the Gas Turbine Drawing Office for:

DRAWING OFFICE CHECKER in this office engaged on the design and application of a diverse range of turbo machinery. Applicants should be between the ages of 30 and 55, have considerable drawing office experience and will be expected to comment on design aspects as well as being responsible for the standard of drawings for high-class machinery. The position entails liaison with Production and Research Departments to assist section leaders in resolving manufacturing problems.

CONTRACT and APPLICATION DRAUGHTSMEN to fill senior posts. They will be responsible for applying various designs of turbo machinery in interesting installations on land, sea and mobile units throughout the world. Applicants must be over 26, have at least 5 years' drawing office experience and be capable of supervising the work of juniors.

DESIGNERS and DESIGN DRAUGHTSMEN to fill two senior posts in connection with new ranges of turbines and associated equipments. Applicants must have design ability and experience, be over 26, have H.N.C. or equivalent and be capable of supervising the work of juniors.

Posts pensionable.—Applications, stating age, qualifications and experience to Manager of Industrial Relations Department, Ruston and Hornsby, Ltd., Lincoln.

E8566 A

SENIOR ELECTRICAL DESIGN ENGINEER required for a firm manufacturing a large range of Industrial Trucks. Applicants must be capable of taking charge of Electrical Design and Development sections and will be responsible to the Chief Designer for design and/or choice of all electrical apparatus required for traction and equipment drives. Only applicants with experience of similar work will be considered.—Applications marked "Confidential" to BOX No. E8580, "The Engineer." A

SENIOR ESTIMATOR, experienced in all classes of Cast Iron and Steel pipework schemes, required by company specialising on contract work for the Chemical, Oil and allied trades. Salary commensurate with the position.—Reply to General Manager, BOX No. E2089, "The Engineer." A

SENIOR MECHANICAL HANDLING DESIGNERS required in Bristol, preferably with colliery equipment experience. Salary £950/£1100 per annum.—BOX No. E8555, "The Engineer." A

STRUCTURAL ENGINEER required for the Design of Steel Structures and Foundations in connection with low temperature chemical plant. Must be able to originate and carry through all necessary designs and calculations.—Reply to Air Products (Great Britain), Limited, 49/50, Poland Street, London, W.1. E8552 A

THE WORLD'S LEADING INVENTORS
and Manufacturers of special-purpose precision machinery for the tobacco industry have opening in their Patent Department for a

TECHNICAL ASSISTANT
(PATENTS)

This is a progressive Senior Staff appointment offering a first-rate opportunity to a suitably qualified man, ideal age about 30, with previous experience in patent practice. The work involves mainly mechanical engineering, but involves also electrical/electronic engineering as an important subsidiary.

Applications, stating age, qualifications and experience should be personally addressed in confidence to the Personnel Manager:

MOLINS MACHINE CO., LTD.,
Evelyn Street, London, S.E.8.

E8369 A

TECHNICAL ASSISTANTS required by pipework contracting company for permanent head office appointments—North West area. Successful applicants will be required to handle contracts through the planning and engineering phases to completion. The duties will also include taking off quantities from pipework drawings and assisting in estimating processes. Good all-round pipework knowledge with drawing office experience is essential. —Reply to General Manager, BOX No. E2088, "The Engineer." A

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COMPANY MEETING

JOHN BROWN AND COMPANY LIMITED

Engineers and Shipbuilders

WIDE DIVERSITY OF GROUP'S ACTIVITIES

NEED FOR A MORE APPROPRIATE SYSTEM OF DEPRECIATION ALLOWANCES

LORD ABERCONWAY'S REVIEW OF OPERATIONS

The ninety-fourth Annual General Meeting of John Brown and Company Limited was held on September 5 at 4, The Sanctuary, Westminster, London, S.W.1.

The Right Hon. Lord Aberconway, the Chairman, presided.

The following is his statement circulated with the report and accounts for the year ended March 31, 1958.

The Company's subsidiaries have traded satisfactorily in a difficult year. Consolidated Profit before taxation was (to the nearest £1,000) £3,336,000, an increase over the previous year of more than £100,000. The Profit and Loss Account benefits from the inclusion, for the first time, of the results of Constructors John Brown Ltd., and so the figures are not strictly comparable with those of the year before.

Taxation provisions of no less than £1,944,000 are required, as against £1,885,000 last year. A provision for taxation of £135,000 made in earlier years and no longer required is brought back ; it compares with special credits last year of £264,000. Thereafter, and after deducting the profits of subsidiaries attributable to other shareholders therein, the balance of profit available is £1,440,000, compared with £1,528,000.

Your directors recommend a final Ordinary dividend of 6% less tax, making for the year a total of 10% less tax. Stockholders will recall being advised last year that dividends thenceforward would be paid less tax, and not free of tax. Last year's total dividend was equal to 5% free of tax. If the proposed final dividend is approved, the available balance of £1,440,000 for the year would be used as to £590,000 in dividends on the Ordinary and Preference Stock, while £850,000 would be added to the amounts carried forward, partly in the books of the Company, partly in those of the subsidiaries.

I would draw stockholders' attention to only one point in the accounts, which otherwise call for no particular comment. The policy of the Company in leaving in the accounts of subsidiaries a substantial proportion of their earnings is the main reason why the value of the interest of the Company in its subsidiaries increases yearly, while the figure at which that value is shown in the Company's own Balance Sheet is not thereby changed. The growing difference is now no less than £4,788,000 between the Company's interest in the net assets of subsidiaries, as shown by the Consolidated Balance Sheet, and the figure at which the Company shows that interest in its own Balance Sheet. I should perhaps add that this is after an exceptional item this year of £486,000, representing the excess of the sale price over the book value of the fixed assets involved in the sale by Wickman Ltd., of its machine tool manufacturing business to a subsidiary. The increase in the figure at which investments in subsidiary companies are shown in the Company's Balance Sheet reflects further cash subscriptions by the Company for shares in subsidiaries.

Shipbuilding

Work in the Shipyard and Engine Works at **Clydebank** continues to expand. The output in tonnage of ships showed an increase over last year, and covered a wide range of types. During the year the output included s.s. "*Sylvania*," the fourth of the large passenger/cargo steamships which Clydebank has been privileged to build for The Cunard Steam-Ship Company's Canadian service ; the s.s. "*British Trader*," the fourth 32,000 ton deadweight tanker for B.P. Tanker Company Ltd. ; and the motor vessel "*Otaio*" for The New Zealand Shipping Company Ltd. ; the first cadet training ship of its kind. Clydebank also completed a 19,000 ton deadweight tanker for The Thompson Steamshipping Company Ltd., and another similar vessel for foreign owners ; and delivered I.N.S. "*Brahmaputra*," a frigate to the Indian Navy, the first vessel of this size to be fitted with controllable pitch propellers.

During the year a contract for a passenger/cargo liner of about 36,000 gross tons was received from The British and Commonwealth Shipping Company Ltd. The large tanker orders yet to lay down should ensure for some years to come full employment for the reconstructed berths in the West Yard, which it is hoped will be fully equipped by the middle of next year.

Undue significance has been attached in some quarters of the Press to adjustments in the building programmes of certain of our clients. The deferment of the laying down of the Cunarder was a matter which Clydebank was readily able to accommodate by bringing forward other contracts instead ; while the decision of The British and Commonwealth Shipping Company Ltd. to change the two tankers ordered to dry cargo ships made no difference to Clydebank. These are difficult times for shipowners, but only a very small proportion of contracts placed in British yards has been cancelled. British shipowners must be congratulated on the robustness of their long-term view.

The modernisation of the Engine Works at Clydebank has increased the capacity for making pressure vessels and other fabrications, and for cutting gears. In the gas turbine field the first peat burning gas turbine is now undergoing trials in the north of Scotland, but the development of some other gas turbines has not been successful and the interest of Clydebank in this field will lessen.

Land Boilers

The Whitecrook works of **John Brown Land Boilers Ltd.** have continued in full production, but the future of this business must be viewed with anxiety. Overseas competition is intense and prices unremunerative. At home the programme officially announced for the provision of electrical generating capacity by way of big nuclear stations has lessened the requirements for new thermal plant ; while the rapid increase in recent years in the size of individual thermal units has severely limited the number of boilers that will be needed every year. The resultant load is quite inadequate to keep even a bare majority of the established manufacturers reasonably employed. The fact therefore has to be faced that there may be a considerable gap in steam generating work available to the company from 1960 onwards, and this is receiving careful attention. It is pertinent in this connection to recall that the Company started in this business at the instance of the Authority.

Nuclear Power

Consideration, jointly with Hawker Siddeley Group Ltd., of the application of nuclear energy to the generation of power in large land stations and to the propulsion of merchant ships has indicated the need for a cautious approach. To enter the field of design of nuclear reactors is a costly operation, by no means certain to be crowned with success. Meanwhile a specialised mechanical engineering design and contracting organisation has been set up by the Company and is concentrating intially upon the business of supplying various components for nuclear work.

Machine Tools and Engineers' Tools

In the machine tool industry a marked recession developed during the year and still persists. Various schemes of industrial re-equipment have recently been completed, and others, possibly on a smaller scale, appear to be held up ; however, some of the recent measures taken by the Chancellor may stimulate activity. **Wickman Ltd.** delivered many more automatic lathes than the number for which it received orders, and its order book is accordingly much smaller. Orders for factored machine tools have fallen off. Wickman's tungsten carbide products maintain their leading position in a highly competitive field.

Webster & Bennett Ltd. achieved a record output of vertical boring mills, following the expansion programmes undertaken during the last three years. Some 43% of the output went to export markets. The order book for the current year is full ; but a diminution in the rate of new orders, coupled with increased production, is resulting in a not wholly unwelcome shortening of the delivery period for future orders.

Firth Brown Tools Ltd. has found that conditions have continued to be highly competitive, both at home and abroad. Nevertheless the wide range and high quality of products on which its business is based have assisted the company to maintain its position. The year's results have, however, been adversely affected by loss of business during the strike in April of last year.

Other U.K. Engineering Interests

Markham & Company Ltd. has despatched before time the first of the Kariba water turbines. Work on the further Kariba turbines, and on several other water turbine orders, continues. World prices for turbines have fallen, while British costs tend to rise, and competition is very keen. Work for the National Coal Board absorbs much of the remaining capacity of Markham's. An interesting piece of equipment, designed and manufactured by Markham's, was a large testing chamber for Normalair Ltd., to simulate conditions of temperature and pressure encountered at high altitudes.

Cravens Ltd. exceeded its record output of the previous year of rolling stock and other engineering products. The extension of its facilities for the manufacture of diesel railcars has improved the efficiency and increased the output of this work. Further substantial orders for railcars have been received from the British Transport Commission for delivery in 1959. Good progress has been made with the manufacture of hydraulic injection moulding, die casting and metal drawing presses. Several machines have been supplied and are operating to the satisfaction of the customers. A variety of specialised engineering equipment for atomic plants has been produced.

S. N. Bridges & Co. Ltd. has again had a successful year with turnover higher by a quarter. A larger works has been bought, which, after modernisation, will make possible a higher output and much greater efficiency. New tools and attachments are being regularly designed and introduced. The electric tool industry is widely known to be passing through difficult times, but Bridges, though experiencing a marked slackening in demand, continues to enjoy a satisfactory share of the market.

Constructors John Brown Ltd. has continued to expand its activities, particularly in the chemical engineering field. A research station has been set up at Leatherhead, and a strong engineering division has been built up, to design and install plants. The company also specialises in automatic control gear associated with such work. A large contract for the design, construction and equipment of a factory for Chemstrand Ltd. at Coleraine in Northern Ireland is making good progress, as also is a similar one for I.C.I. at Heysham.

C.J.B., as this company is widely called, has continued to be active in the gas industry. It has carried out an important design study for the Ministry of Power on a large plant to gasify coal and to make petroleum products and town gas. It has also built for the Ministry a second experimental slagging gasifier which it is now commissioning.

Abroad, in a joint venture with Williams Bros. of Tulsa, U.S.A., C.J.B. is carrying out pipelining contracts in Persia, Turkey and Austria. Together with four other firms the joint venture has entered into a contract with the Oil Consortium in Abadan to undertake the large Kharg Island development.

As substantial shareholders in Westland Aircraft Ltd. we note with pleasure the achievements of this progressive company. As has been announced, the first production "WESSEX," the gas turbine helicopter for the Royal Navy, has flown five months in advance of programme, and, though originally a private venture, this type is now the subject of substantial orders. The first flight has also been announced of the large helicopter with twin gas turbine engines, the "WESTMINSTER," which has been developed in the crane version as a private venture. Stockholders will have read of the heliport in London which Westland is equipping and proposing to operate.

Overseas

The Canadian subsidiaries of the Company continue to operate satisfactorily and to render an important service to local industry. Their profit margins have, however, been adversely affected by the increasing severity in recent months of the Canadian recession. Your directors continue, however, to have great faith in the long-term industrial future of Canada and in the sound basis of the Company's enterprises in the Dominion.

In Rhodesia the general economic difficulties caused by the heavy falls in the prices of copper and other commodities have resulted in a shortage of orders on the books of **F. Issels & Son.** Despite its excellent facilities, this general engineering firm finds competition severe, particularly from the Union. **Rhodesian Alloys (Pvt.) Ltd.** occupies a position of increasing importance as the new basic industry of the Federation ; production at Gwelo has continued at an excellent level, but anxiety is now being felt at the very low prices that countries behind the Iron Curtain are quoting for low-carbon ferro-chrome, among other metals. Indeed, low-carbon ferro-chrome is one of the few commodities which sell to-day for less than twice the 1935 price.

Elsewhere in the Commonwealth, subsidiaries make progress and consolidate their businesses. In the Union of South Africa, however, intense competition makes much of the trading of subsidiaries unremunerative.

With the wide diversity of the Company's activities at home, the development of relations between Great Britain and the European Economic Community is being followed with great interest. The Company's business on balance should not suffer from the setting up of a free trade area in Europe. It is easy for hostile critics of the plan to point to many individual industries or businesses in this country which will suffer thereby, but in the main, so long as Britain's technical prowess remains, the benefits of an extended market should outweigh the disadvantages of increased competition at home from overseas manufacturers.

Problem of Plant Replacement

The extension this year of Initial Allowances eases somewhat the immediate tax burden suffered by enterprises faced, as are all the subsidiaries of the Company, with the necessity regularly to replace their equipment with the very best. But Initial Allowances only bring forward to an earlier stage in the life of a new machine the incidence of wear and tear allowances ; they do nothing to help industrialists to solve the problem of how to put aside out of profits, in times of grievously heavy taxation, enough to replace old equipment with more expensive new.

It would have been more helpful to industry if the Chancellor had restored Investment Allowances on industrial plant ; their introduction was a step forward and their abolition a step backwards. Investment Allowances did permit, in respect of new plant, the owner to set aside during its life, before taxation, a sum towards its replacement greater than its original cost ; even so, the Allowance being an arbitrary percentage with no provision for adjustment, that increased sum may or may not prove sufficient to provide in due course for the replacement of the plant.

It should not be beyond the wit of man to devise some reasonable index whereby, over the life of a piece of equipment, sufficient, and no more, could be set aside by way of wear and tear allowance to provide its owner with the full means of replacing it ; according to the measure of inflation or deflation during its life, so would the owner at the end have been allowed to set aside before taxation proportionately more or less than its original cost.

My remarks on depreciation allowances have so far referred only to new plant, but the real need of industry is for existing plant to be the subject of fair and proper depreciation allowances based on replacement, not original cost. Initial Allowances and Investment Allowances apply only to new plant, but the system which I have outlined could readily be adapted to existing plant. The need for a more appropriate system of depreciation allowances would be more widely recognised if there were less tacit acceptance of the definition of profits as the balance remaining after enough has been set aside towards the recovery of the original cost of plant : and, instead, fuller realisation that a much greater contribution to meet the enhanced cost of plant replacement needs to be set aside before profit is struck. The provision of such funds should be a joint affair : the Chancellor contributing by remission of tax, and the owner contributing the balance from his profit. If wear and tear allowances for tax purposes could be more adequate, industrialists would not object to a corresponding obligation upon them to set aside towards cost of replacement the relevant amount of profit as well as the tax relief.

Directorate

Sir Stanley Rawson has intimated his desire to be relieved of the executive duties which he has carried out so admirably for many years. He accordingly has given up the chairmanship of Wickman Ltd., Constructors John Brown Ltd. and John Brown Land Boilers Ltd. He will, however, remain a director of the subsidiaries (including these three) with which he has been more closely connected, and will continue as vice-chairman of John Brown and Company Ltd. In accordance with the expressed wishes of our colleagues, I have become chairman of Wickman Ltd. and of Constructors John Brown Ltd., and Mr. Eric Mensforth chairman of John Brown Land Boilers Ltd.

My colleagues concur with my view that it is only right that I should sound the various notes of caution that run through this statement. Yet, by and large, your board is confident that, given reasonable trading conditions, the Company can squarely meet whatever is in store. For this feeling, the skill, industry and loyalty of the management and staff in each of the Company's establishments are largely responsible. To them and to our workpeople the thanks of the stockholders and of the directors are due.

The report and accounts were adopted and the other formal business duly transacted.

SITUATIONS VACANT

THE UNITED GLASS BOTTLE MANUFACTURERS, LTD. are one of the largest glass container manufacturers in Europe, and have factories in various parts of the country. At St. Helens, Lancashire, there are vacancies for :—

DESIGN ENGINEER DRAUGHTSMEN, Senior and Junior, with experience in design and detail design of Medium Heavy Special Purpose Machines, and devices for the manufacture of glass containers and special ware.

PLANT LAYOUT DRAUGHTSMEN, Senior, for Works Engineers Office. Estimating experience essential.

These positions offer scope and good prospects for men with imagination and the ability to get things done.

An excellent Superannuation and Life Assurance Scheme is in operation.

Applications giving age and details of qualifications and experience should be sent to the Personnel Officer, Sherdley Works, St. Helens.

E8572 A

WELDING ENGINEER required by a medium-sized engineering company in the western district of Glasgow. Must have practical experience in welding and radiography for Class I pressure vessel work to Lloyd's, Asme and other codes. Experience of automatic machine welding essential.

It would be an advantage to have attended at Lloyd's approved Course in Casting and Weld Radiography.

Staff position with superannuation. Good canteen facilities available. Salary will be commensurate with technical qualifications and experience. Applications, giving age and experience.—BOX No. E2083, "The Engineer."

A

WEST MIDDLESEX FIRM require immediately a competent ENGINEERING DRAUGHTSMAN, fully experienced in design of electro-mechanical devices.—BOX No. E136, "The Engineer." A

WORKS MANAGER required for West Yorkshire factory by a firm of Mechanical and Electrical Engineers specialising in light engineering. A sound knowledge of press, capstan and welding work is essential. The man appointed must be a good disciplinarian with a knowledge of production control methods. House available. Applications, stating age, experience and salary required.—BOX No. E2087, "The Engineer." A

YOUNG ENGINEER required by a Company specialising in non-ferrous metals, for handling projects from the design stage on the drawing board, following through to machine construction and running in on the shop floor. A sound practical training and knowledge of engineering services is essential. Experience of non-ferrous metals would be an advantage. Candidates, who should be between 23–30, should write, giving full details of experience, qualifications, age, &c.—BOX No. E8403, "The Engineer." A

SENIOR DRAUGHTSMEN
DESIGN ENGINEERS
and
DESIGN DRAUGHTSMEN

are offered progressive posts at

STEWARTS and LLOYDS
LIMITED · CORBY

. . . one of the largest integrated Iron, Steel and Steel Tube Works in Europe

MECHANICAL ENGINEERING

1. Department of New Development. For the design and development of plant and equipment. Applicants must have sound knowledge of heavy engineering, preferably in an Iron and Steel Works, and considerable experience of design work.

2. Tube Works Drawing Office. Senior Draughtsmen for layout, maintenance and improvement of plant and equipment. Applicants must have H.N.C., along with sound Drawing-Office experience in heavy engineering.

ELECTRICAL ENGINEERING

3. Department of New Development. For design of electrical equipment. Applicants must have a thorough knowledge of distribution and good Drawing Office experience.

Five-day week. Good welfare, canteen and recreational facilities. Superannuation and Life Assurance Schemes. Staff Hostel for single men. Excellent housing prospects. Good salaries based on experience and qualifications.

Applications will be treated as confidential, and should give age, details of qualifications, experience, salary required, department to which application refers. They should be addressed to :

Manager/Personnel,
STEWARTS AND LLOYDS, LIMITED,
Corby, Northants.

E135 A

SITUATIONS VACANT

TOOL ROOM SUPERINTENDENT

A leading Merseyside Engineering Works, engaged on light and medium precision machining and assembly, require a SUPERINTENDENT for their Tool Room. The post will carry senior responsibility with good salary and superannuation.—Please write, giving particulars of training and career to date to BOX No. E4023, LPE, Romano House, 399-401, Strand, London, W.C.2.

E8506 A

WELDING ENGINEER

required to control site welding of large oil storage tanks. The Welding Engineer will be responsible for advising on welding problems arising at any stage during site welding of tankage, and should have a thorough knowledge of welding codes, modern site welding techniques, and all forms of non-destructive testing. Position incorporates Non-Contributory Pension Scheme—Apply stating age, qualifications and previous experience to The Erection Manager, Wm. Neill & Son (St. Helens), Ltd., 38, Victoria Street, Westminster, London, S.W.1.

E8516 A

MSL

have been retained to advise on the appointment of a

GEAR SPECIALIST

for a company with a high reputation in the design and manufacture of machine tools and specialised equipment. The appointment will be centred in the Birmingham area, although it would be possible to operate from the company's London office in exceptional cases.

The Gear Specialist will be responsible to the Technical Sales Manager and he will be expected to deal with all gear problems both from the design and manufacturing aspects. He will work closely with the sales organisation as the company's specialist in this field, and a certain amount of overseas travel will be necessary.

Candidates should have served an apprenticeship in precision engineering, have had design office experience and possess extensive knowledge of the design of gears and modern gear processing machine tools. A degree or A.M.I.Mech.E. is essential, together with an intimate knowledge of the trade.

Preferred age 35–45. Remuneration will be approximately £1,750 to start, with good prospects of promotion. The company will provide a car and will assist with removal expenses and housing, if necessary.

No information will be disclosed to our clients until candidates know their identity and have given permission after personal discussion. Please send brief details in confidence, quoting reference G.1104, to M. B. Berks.

MANAGEMENT SELECTION LIMITED
17, Stratton Street, London, W.1.

E134 A

SITUATIONS VACANT

RESIDENT ENGINEER

Required to supervise the construction of welded oil storage tanks on large-scale projects in Wales and the south of England. Duties will include organisation and supervision of direct labour. This is a senior appointment and applicants must have been previously employed in a similar capacity on such work. Position incorporates Non-Contributory Pension Scheme.—Apply, stating age, qualifications and previous experience to The Erection Manager, Wm. Neill and Son (St. Helens), Ltd., 38, Victoria Street, Westminster, London, S.W.1

E8498 A

RICHARDSONS WESTGARTH (HARTLEPOOL) LIMITED

CHIEF MECHANICAL ENGINEER

Applications are invited for the post of CHIEF MECHANICAL ENGINEER, to be responsible for all matters relating to the design, testing and commissioning of large turbo-generator and condensing plant for conventional and nuclear power stations, gas turbines, compressors and blowers, &c.

Candidates must be Chartered Mechanical Engineers and have had previous experience in administration of technical and drawing-office staff.

Excellent prospects, and remuneration commensurate with qualifications and experience. Pension and Life Assurance benefits and Service Agreement.

Applications, which will be treated in strict confidence, giving details of qualifications and experience, together with chronological list of previous appointments, should be addressed to the Managing Director, Richardsons Westgarth (Hartlepool), Ltd., Hartlepool, and marked "C.M.E. Strictly Confidential."

E8514 A

A.E.I.—HOTPOINT LIMITED

As part of a major expansion programme, the following vacancies have arisen in this well-known and virile Company :—

SENIOR DESIGN ENGINEERS

within the fields of Refrigerator and Washing Machine design and development.

Applicants should possess good engineering qualifications to degree standard. In addition they should have some years of experience within the light engineering industry. Domestic appliance experience is not essential though desirable.

SENIOR PRODUCTION ENGINEERS

Applicants should have good engineering qualifications to degree standard. They should be familiar with production planning and/or jig and tool design, etc., for large batch production and flow-line assembly in the light engineering field.

These vacancies occur in a successful Company, whose standards of salary, pension, etc., are attractive, and which expects a high standard of ability and initiative in its staff. The posts are situated in the pleasant market town of Peterborough and assistance with housing will be given in approved cases.

Applications should be made to :
The Personnel Manager, A.E.I.-Hotpoint, Ltd., Crown House, Aldwych, London, W.C.2

E8560 A

ASSISTANT TO
MANAGING DIRECTOR

This position offers opportunity to be trained in all phases of this Company's operations, in preparation for high administrative position.

COMMENCING SALARY : £5000–£6000 p.a.

Candidates must have engineering background, and preferably be University graduates or the equivalent. Experience should cover design and manufacturing problems, as well as broad commercial understanding and outlook. It is also desirable that candidates should have understanding or experience in the techniques of Management, including Production Control, Work Study and Financial Control. Knowledge of machine tools and current machinery developments important.

Candidates should be between 35 and 45 years of age, and must have had administrative responsibility in a large organisation.

The Company is located in a desirable part of England.

Reply in confidence, giving age, education, experience, salaries earned, to BOX No. E2086, "The Engineer."

SITUATIONS VACANT

BRITISH OXYGEN GASES LIMITED

AIRCRAFT EQUIPMENT WORKS, PINNACLES, HARLOW.

SENIOR AND JUNIOR DRAUGHTSMEN

are required for the design of oxygen equipment.

For the senior posts candidates should have some workshop training and be experienced in the design of light mechanical equipment or mechanisms.

Excellent working conditions, canteen, pension fund. Rented accommodation is readily available at Harlow.

Applications to :
Personnel Manager,
Spencer House,
St. James's Place, London, S.W.1.

E8549 A

DESIGN ENGINEERS

required for development section of drawing office engaged on forward projects for mining, crushing and earth-moving machinery. Experience in any of these branches, or specialised experience in hydraulics and/or transmissions, would be an advantage. These are senior positions and applicants must have initiative and be capable of working with minimum supervision. Prospects are excellent, in a long-established and expanding Company.—Applicants should give full details of age, career, experience and technical qualifications, with salary required.—Address applications to The Secretary, British Jeffrey-Diamond, Ltd., Stennard Works, Wakefield.

E8539 A

SITUATIONS VACANT

MAINTENANCE ENGINEER

INDIA

A Maintenance Engineer required for expanding British factory near Calcutta. After training in London, the successful candidate will be required to take over the Maintenance Department in India towards the end of 1959. Applicants, who should be keen to make a career in India, should be about 30 years of age, have served a good engineering apprenticeship and preferably have supervisory experience in factory maintenance. H.N.C. mechanical engineering is desirable but sound practical experience and managerial ability are the most important qualifications.

Generous salary and leave terms, free accommodation and medical attention are provided. The post is pensionable. The commencing salary will be related to qualifications and experience.—Written applications should include full details of qualifications and experience and be addressed to BOX "C.R.," c/o J. W. Vickers and Co., Ltd., 7-8, Great Winchester Street, London, E.C.2.

E8538 A

SENIOR DRAUGHTSMAN

required, aged 24–28, for the Engineering department in London of a fast-growing and famous manufacturing organisation.

The successful candidate will have a sound educational background, preferably to H.N.C. level, and will have followed a recognised apprenticeship. He will also possess experience and knowledge of machine design and Plant Layout work.

This position, which may lead to advancement as Project Engineer within 12 months, provides a valuable opportunity for a person of ambition and ability, and offers an attractive starting salary. A Pension Scheme ensures security.—Write fully, with details of age, education and experience to BOX No. E8540, "The Engineer."

A

TURBO-MACHINERY DEVELOPMENT WORK

A Group of Companies, with its Headquarters on the North East Coast, engaged in a wide field of activity in mechanical engineering, has a vacancy in its Development Drawing-Office.

The post calls for the ability to organise and develop new procedures and methods required in connection with work on turbo-machinery and on nuclear power ancillary plant. Considerable experience in this class of work is essential. The post offers considerable scope and opportunity for advancement.

Applications, which will be treated in strict confidence, should be sent, in the first instance, to BOX No. E8537, "The Engineer." A

ROTATING ELECTRICAL MACHINE DESIGNER

The HARLAND ENGINEERING COMPANY, LTD., ALLOA, SCOTLAND, have a vacancy for a young engineer possessing University degree or good H.N.C. and with several years' rotating electrical machine design experience. In addition to specialist products the work covers approx. range 100 to 10,000 h.p./kW, both A.C. and D.C. 5-day week. Good contributory pension scheme.—Applications, which will be treated in strict confidence, should state age and give full details of training, experience, qualifications and salary desired. Write to Personnel Manager.

E8550 A

SITUATIONS VACANT

PILKINGTON BROTHERS

LIMITED

MECHANICAL ENGINEER

required for the maintenance and installation of heavy industrial plant. Applicants should have a good engineering background, a degree, and professional qualification. The post involves responsibility for plant worth several million pounds and control of a labour force of 650. Preferred age 35–50. Apply stating age, qualifications, experience and present salary to :

PERSONNEL OFFICER
(GRADUATE RECRUITMENT)
PILKINGTON BROTHERS,
LIMITED,
ST. HELENS, LANCS.

E8543 A

SITUATIONS WANTED

ENGINEER (33), seeks responsible position. Conscientious, reliable and adaptable. B.Sc.(Eng.), A.M.I.MechE., A.M.I.W.M. Apprenticeship, 7 years Design, 6 years Works Management, medium and heavy mechanical engineering. Present Salary £1420 p.a.—BOX No. E2090, "The Engineer." B

BUSINESSES and PREMISES

CITY BORDERS, E.C.2. New Commercial and Industrial Building. Area about 20,000 sq. ft. Ground Floor Showroom. Goods Lift. Central heating. Good loading bay. New Lease at low rent of £8250 p.a. excl. Inspection strongly recommended.—Apply : Chamberlain and Willows, 23, Moorgate, E.C.2. (MET 8001). E8531 L

PATENTS

THE PROPRIETOR of British Patent No. 590,586, entitled "IMPROVEMENTS IN HYDRAULIC POWER TRANSMISSION MEANS," offers same for licence or otherwise to ensure its practical working in Great Britain.—Inquiries to Singer, Stern and Carlberg, Chrysler Building, New York, 17, New York, U.S.A. E8507 H

THE PROPRIETOR of British Patent No. 731,245 for "LOAD HANDLING EQUIPMENT FOR CARRIAGE ON VEHICLES," desires to enter into negotiations with a firm or firms for the sale of the patent or for the grant of licences thereunder.—Further particulars may be obtained from Marks and Clerk, 57 and 58, Lincoln's Inn Fields, London, W.C.2. E8520 H

SUB-CONTRACTING

CASTINGS.—We can save your porous castings, ferrous or non-ferrous, by an approved impregnation process ; sample castings treated ; A.I.D. approved.—Recupero, Ltd., 66, South Harrow Viaduct, Harrow, Middlesex ('Phone, Byron 1178). E109 MW

KELLERING AND CAM PROFILING capacity up to 8ft. by 6ft. or 6ft. diameter.—ARMYTAGE BROS. (KNOTTINGLEY), Ltd., The Foundry Knottingley, Yorkshire (Telephone : Knottingley 2743/4). E116 MW

PRATCHITT BROTHERS, LTD., Denton Iron Works, Carlisle, having well-equipped engineering shops and ironfoundry, invite enquiries for General Engineering, Structural and Platework, from firms wishing to have plant made to their own designs and specifications. E751 MW

PRECISION ENGINEERS.—Personal service for prototypes, small quantity machined parts and equipments. Design and development undertaken. A.I.D. Approved.—Bowyer, Smyth and Partners, Ltd., Vineyard Walk, Clerkenwell, E.C.1 ('Phone, TERminus 5113/4). E112 MW

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LATTICE STEEL Erection Masts (light and heavy), 30ft. to 150ft. high, for immediate hire.—Bellman's, 21, Hobart House, Grosvenor Place, S.W.1 ('Phone, SLOane 5259). E105 K

HIRE A £1500 CAMERA FOR ONLY £5. All other types of photographic equipment available.—B. Bennett and Sons, Ltd., 25/27, Oxford Street, London, W.1 (Telephone, GERard 9953). Catalogue on request. E128 K

MISCELLANEOUS

TIME RECORDERS, Sales, Rentals, Service, Telephone Hop 2239.—Time Recorder Supply and Maintenance Co. Ltd., 157–159, Borough High Street, London, S.E.1. E110 I

MACHINERY Etc. WANTED

WANTED, Machines of all Types.
CASH PAID.
Norman E. Potts (B'ham), Ltd., 130, Mossley Road, Birmingham, 12. VIC. 1278, 1279, 1270, 0856. E104 F

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at
READS AND BARRONS MIXERS, LTD., DRUMMOND ROAD, FISHPONDS, BRISTOL
ON VIEW: Tuesday, 16th, and Wednesday, 17th September, 10 a.m.–4 p.m.

BEDFORD 5-TON LORRY
Long wheel base, Sept., 55.

MACHINE SHOP TOOLS & EQUIPMENT
7in. Woodhouse and Mitchell, Dec., 54, Centre Lathe.
14in. Centre Lathe.
Blacksmith's forge.
Drilling machines.
Screwing machine.
Linisher.
Treadle guillotine (4ft.).
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BAKEHOUSE EQUIPMENT
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Galvanised tanks.

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ELECTRIC MOTORS & STARTERS, ETC.

OFFICE FURNITURE
Desks, Filing Cabinets, Typewriters.
Send stamped, addressed envelope for Catalogue and Tender Form to Owner's Agents, Allwright and Stiles, 53, Clarendon Road, Watford. Gadebrook 3444. E8477

600

FOUR 400 h.p. ROLLING MILL SLIPRING MOTORS by E.E.C. wound for 415/3/50 738 r.p.m., coupled to Gearbox by Power Plant Co., final speed 30 r.p.m. High Speed shaft with two flywheels—total kinetic energy 10,000 h.p. seconds. 30 h.p. barring Motor and automatic Igranic control gear with slip-resistance.
750 h.p. ROLLING MILL MOTOR by Brown Boveri, date 1954 ; 2200/3/50, 146 r.p.m.

GEORGE COHEN,
SONS AND CO. LTD.
WOOD LANE, LONDON, W.12
Tel. : Shepherds Bush 2070 and
STANNINGLEY, NR. LEEDS.
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GRINDING MACHINES

New OLIVETTI HYDRAULIC PRODUCTION GRINDING MACHINES
Capacity 13¾in. diameter by 48in. long ; max. distance between centres 53in. Machine equiiped for plunge grinding. Late type machines.

F. J. EDWARDS LTD.,
359–361, EUSTON ROAD,
LONDON, N.W.1.
EUSton 4681 and 3771.

E8533 G

SOAG

MASSEY 5-cwt. Pneumatic Clear Space Swaging Hammer, late type, with direct motor drive from foot mounted motor on rear, special guide to ram, for stamping in dies, &c. Hand and foot control. Stroke 16in. No. of blows per minute 172, h.p. motor 30. In excellent condition.

INSPECTION INVITED.
BUY NOW AND SAVE MONEY
Full details from :—
SOAG MACHINE TOOLS, LTD.,
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'Phone : RELiance 7201.
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E212 G

FOR SALE
320ft. of 18in. by 2½in. dia. Roller Conveyor and Stands.
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130ft. of Steel Double Sided Work Tables.
2 Overhead Flowline Chain Conveyors. Complete with Drive Units.
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FERRANTI, LTD.
(Disposals Department),
HOLLINWOOD, LANCS. E8541 G

UNUSED SET OF PLATE BENDING ROLLS, capacity 32ft. by 1in. down to 6ft. by 2½in. mild steel plate ; 75 h.p. roll drive, 40 h.p. screw-down ; electrics 400/3/50.—BOX No. E8327, "The Engineer." G

Classified Advts. continued on page 128

FOR SALE

FRED WATKINS (ENGINEERING), LTD.

STEAM BOILERS.—Cochran Vertical (New), 8ft. 6in., 8ft., 7ft. 6in., 7ft. and 6ft. in dia., 100/150 lb. w.p.; reconditioned 8ft. 6in. down to 3ft. dia.; Economic 4ft. to 11ft. 6in. dia., including new 7ft. and 8ft. dia., 150, 180 and 200 lb. w.p.; 300 reconditioned Vertical Crosstube, all sizes.
AIR COMPRESSORS.—Broomwade 400, 300, 200 and 130 cu. ft.; all motorised; Reavell Rotary Blowers, 2000 c.f.m., 3–2 p.s.i.
200 AIR RECEIVERS, stocked up to 9ft. dia., 100 to 500 lb. pressure.
ELECTRIC MOTORS.—150 Totally Enclosed and Flameproof Motors up to 100 h.p.
CRANES.—Mobile 10-ton Lorain, lorry mounted, 30ft.–70ft. extendable jib; 6-ton and 4-ton Coles Diesel-Electric; 3-ton Jones Super 40 (3); Neals 2-ton Diesel, 20ft. jibs (2); Derrick, 5-ton Butters Electric travelling type, 90ft. jib; 5-ton Wilson Electric, 70ft. jib; Steam Loco, 18-ton Brownhoist, 50ft. jib; 10-ton Coles, 40ft. jib; 8-ton Wilson, 35ft. jib; 5-ton Smith, 50ft. jib; 5-ton Cowans Sheldon, 50ft. jib; 5-ton Grafton, 38ft. jib; E.O.T., 40-ton Adamson, 42ft. span; 20-ton Vaughan, 42ft. span (8); Goliath, 40ft. span, 60-ton Clyde, 40-ton Babcock, 10-ton Morris; 5-ton Henderson, 24ft. 7½in. span, 1946; 5-ton King, 29ft. 3in. span; 2-ton Morris, 18ft. span, 2-ton Smith, 34ft. span.
LOCOS.—Fowler Diesel, 150 h.p. (2); Ruston Diesel, 80/88 h.p., new 1942; Hunslet 0–6–0, 18in. by 26in., new 1944; Bagnall 14in. by 22in., two oil fired, one coal; Peckett Steam, 7in. by 12in., 1941; Also 3 miles track, 24in. gauge Bogies, Turnouts, &c.
STEEL PIPING.—50,000ft., 2in. Galvanised, new; 60,000ft., 3in. black new; 5000ft., 8in. seamless; 1000ft., 12in. seamless; 500ft., 14in. seamless; 400ft., 18in. riveted; 280ft., 21in. o.d. welded flanged; 3800ft., 21in. seamless flanged; 500ft., 24in. riveted; 1450ft., 27in. o.d. welded flanged; 216ft., 48in. riveted; 216ft., 60in. riveted.
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STORAGE TANKS.—300 cylindrical and rectangular up to 12,000 gallons, for oil and petrol, also sectional steel and cast iron up to 50,000 gallons.
MACHINE TOOLS.—Scriven Plate Bending Rolls, 14ft. by ¾in.; Robertson Straightening Rolls, 8ft. 6in. by ¾in.; Berry Bending Rolls, 7ft. by ¾in.; Tangye 200-ton Hydraulic Vertical Straightening Press, 15ft. by 3ft. table; Herbert 3ND Miller, 61in. by 15in. table; Pels Punch and Shears, ¾in. capacity; nine new 2 cwt. and 1 cwt. Pneumatic Hammers.

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COLEFORD, GLOS.
'Phone : Coleford 2271/2. E106 G

600

HYDRAULIC PRESSES

1500-ton Downstroke by JOHN SHAW, ram 36in. diam., 36in. stroke, tables 60in. by 42in., daylight 62in., W.P. 1¼ tons/sq. inch.
750-ton Downstroke by T. H. & J. DANIELS, 22in. diam., ram 33in. stroke, tables 56in. by 42in., daylight 55in., W.P. 4500 lb./sq. inch.
500-ton Downstroke by HYDRAULIC ENGINEERING CO., Chester, ram 18in. diam., 30in. stroke, tables 54in. by 42in., daylight 60in., W.P. 2 tons/sq. inch.

GEORGE COHEN,
SONS AND CO. LTD.
SUNBEAM ROAD, N.W.10. Tel.: Elgar 7222/7.
STANNINGLEY, NR. LEEDS. Tel.: Pudsey 2241.
E204 G

METROPOLITAN-VICKERS 500 H.P. SLIP-RING ELECTRIC MOTOR, 196 r.p.m., 400/440/3/50 cycles, complete with control panel and reduction gearbox, giving a final speed of 8·1 r.p.m.
Motor and gearbox available separately if required.

JOHN CASHMORE, LTD.
Newport, Mon.
Tel.: Newport 66941 (6 lines).
E120 G

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30 C.F.M. BELLISS & MORCOM High Pressure Air Compressor, 3 stage, water cooled, 3500 lb. W.P. max. Vee rope drive. In excellent condition. IN STOCK FOR IMMEDIATE DELIVERY
PRICE : £125.
Motorised Air Compressor Sets in stock up to 750 c.f.m.
G. E. SIMM (MACHINERY) LIMITED
27, BROOMGROVE ROAD,
SHEFFIELD, 10. E8495 G

FOR DISPOSAL, One 15-ton NAVVY BOILER ex Steam Navvy. Boiler approximately 27 years old. Completely retubed four years ago. Approximately 5ft. diameter, 13ft. high (minus the chimney).—For further details interested parties should write—Reference P/EB., Appleby-Frodingham Steel Company, Scunthorpe, Lincs. E8510 G

35-TON ELECTRIC PORTAL WHARF CRANE built 1945. 35 tons at 60ft. fixed radius, 85ft. height of lift. Rail gauge 40ft. admitting 3 lines of standard gauge track. Electrics 440/3/50 with Ward Leonard Generator.—REED BROTHERS (ENGINEERING), LTD. Replant Works, Woolwich Industrial Estate, London, S.E.18 Telephone : Woolwich 7611/6. E8576 G

NEW ¾IN. GUILLOTINE for sale. Ex Stock. Motorised Overcrank type, cutting width 8ft. 4½in., Auto hold-down and all necessary gauges, depth of gap in open ends 9¾in., weight 17½ tons, photo, &c., from F. J. Edwards, Ltd., 359, Euston Road, London, N.W.1, or 41, Water Street, Birmingham, 3. E8571 G

FOR SALE

SERVICE EDWARDS VALUE!

JOHN HANDS Double-Sided Friction Screw Press, arranged motor drive for 400/440/3/50, fitted with Broughton automatic press guard, pressure exerted approximately 60 tons, maximum stroke 18in., between uprights 37½in., tee slotted bed 36in. by 46in.
BLISS No. 1 Double-Sided, Double-Action, Geared Toggle Drawing Press, arranged for belt drive, punch stroke 7in., blankholder stroke 4½in., between uprights 17in., size of bed 16in. by 18⅜in., hole in bed 6½in. diameter.
CRAIG & DONALD Model 400/10, All Steel Motorised Double-Geared Press Brake of steel plate construction, arranged motor drive for 440/3/50, pressure exerted approximately 400 tons, former capacity 10ft. by ¾in., width between side frames 82in., stroke approximately 4in.
NEW BESCO 8ft. 4in. by ¼in. Type HK, All Steel Undercrank Open Ended Production Power Guillotine of all steel construction, arranged motor drive for 400/440/3/50, length of blades 110¼in., capacity ⅝in., gap in side frames 3½in., strokes per minute 54.
SCHULER Model BAN, Power Geared Rolling Machine, specially designed for producing double hooks on drum bodies prior to forming, arranged motor drive for 400/440/3/50, maximum working length 41¾in., driving pulley 11in. diameter by 2½in. face, grooved for three ¾in. vee ropes.
INCANDESCENT Forced Draught Bar Heating Furnace, Double-Ended, gas fitted, heating chamber 36in. wide by 24in. deep by 9in. high, total length through furnace 32in. working, temperature range 900 deg. to 1350 deg. Cent.; 1200 deg. Cent., can be reached in about 1¼ hours after starting from cold.
Photographs of the above are available.

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Of Every Description, Attractive Prices.

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LANSDOWNE HOUSE, 41, WATER STREET,
BIRMINGHAM, 3.
Telephone : Central 7606–8. E207 G

TWW

EX-STOCK

NEW RIGIVA MODEL U6 UNIVERSAL MILLING MACHINE, working surface 39⅜in. by 9¾in.
NEW RIGIVA MODEL U20 UNIVERSAL MILLING MACHINE, working surface 55in. by 11⅛in.
NEW RIGIVA MODEL U8 UNIVERSAL MILLING MACHINE, working surface 47¼in. by 11in.
NEW RIGIVA V 20 B PRECISION VERTICAL MILLING MACHINE, working surface 55in. by 13⅛in.
NEW RIGIVA U O PLAIN HORIZONTAL MILLING MACHINE, working surface 27in. by 8in.

THOS. W. WARD LTD.
ALBION WORKS – – – SHEFFIELD
'Phone : 26311. 'Grams : "Forward."
E215 G

HYDRAULIC PRESSES

Unused 4000-ton HYDRAULIC HEAVY PLATE FORMING and BENDING PRESS, table 18ft. by 10ft., weight 380 tons.
2000-ton DOWN-STROKE HYDRAULIC FORGING PRESS, ram 31in. dia., admits 8ft. 7in. wide with horizontal sliding table, weight 200 tons.
1000-ton DOWN-STROKE PRESS by Loewy Eng., ram 27in. dia., bed 40in. by 48in.
650-ton DOUBLE-ACTION DRAWING PRESS by Lake Erie, bed 7ft. 6in. by 6ft. 8in., with self-contained pump unit.
MANY OTHER HYDRAULIC PRESSES OF ALL TYPES

REED BROTHERS (ENGINEERING), LTD.,
Replant Works,
Woolwich Industrial Estate,
London, S.E.18.
Telephone : Woolwich 7611/6.
E8483 G

600

Two 1000kW. BELLISS & MORCOM/HARLAND ENG. CO., LTD., back pressure type Turbo-Alternator Sets for 3300/3/50, designed to work with steam at 195 p.s.i., exhausting against 15 lb. back pressure.
New 20,000 c.f.m. Turbo-Compressor by DANIEL ADAMSON, 100 p.s.i., direct-coupled through gearbox to 4145 h.p. synchronous motor by Met.-Vick., 6·6kV./3/50, with control gear and all standard ancillaries.
Two New 1050kVA., 440/3/50, 4-wire Diesel-engine driven Alternator Sets by MIRRLEES/E.C.C., speed 428 r.p.m., with control gear and standard ancillaries, also starting equipment.

GEORGE COHEN,
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SPECIAL OFFERS
FOR PROMPT CLEARANCE
FROM MODERN POWER STATION

Three THOMPSON WATER-TUBE BOILERS, 26,000 lb. per hour evaporation, each 275 p.s.i.g., with chain grate stoker and accessories.
Two WEIR BOILER FEED PUMPS, 9in. by 12in. by 24in., 7200 g.p.h.
WEIR STAINLESS STEEL STEAM TURBINE-DRIVEN PUMP for boiler feeding, 2000 g.p.h., 200/265 p.s.i.g. Unused.
MISCELLANEOUS BOILER HOUSE PLANT AND EQUIPMENT
1500/2200kW. Condensing or Pass-out TURBO-ALTERNATOR SET by ALLEN/E.C.C., 275 p.s.i.g., 750 deg. F., gearbox, 6000/1000 r.p.m., 2750kVA. alternator, 400/440 volts, 3 phase, 50 cycles, 3600 amps., with control gear accessories, surface condenser and pumping set. Will consider sale of separate components.
"AULDS" REDUCING VALVE AND DE-SUPERHEATER, 275 down to 30 p.s.i.g., 12in. inlet, 18in. discharge.
COPPER BUS BAR, 4in. by ¼in., with two 2000 amp. isolators.
About 2500 yards P.I.L.C.A. POWER CABLE, including 4-core 0·3in. section, 3-core 0·15in. section, 3-core 0·3in. and 3-core 0·25in.
KENT STEAM FLOW METERING PANEL, 70,000/100,000 lb/hr.
170kVA., 134kW. ALTERNATOR by BRUSH, for "V" belt drive, 400/440 volts, 3 phase, 50 cycles, 1000 r.p.m., with control gear.
200 h.p. Vertical. 3-cylinder, DIESEL ENGINE by CROSSLEY PCQ3, r.p.m. 500, with pressure blower, starting set and accessories.
12in. ALLEN CENTRIFUGAL PUMP, 3000 g.p.m., 40ft. head, 965 r.p.m.
63 h.p. SLIPRING MOTOR, 965 r.p.m., with starter.
14/16in. CENTRIFUGAL WATER PUMP by ALLEN, 20ft. head, 975 r.p.m.
56 h.p. SQUIRREL CAGE MOTOR, 975 r.p.m., with starter.
Two 4/6in. CENTRIFUGAL WATER PUMPS by WORTHINGTON SIMPSON, 833 g.p.m., 40ft. head, 1440 r.p.m.
Two 11 h.p. SQUIRREL CAGE MOTORS, 1440 r.p.m., with starters.
Two 4in. CENTRIFUGAL PUMPS by HARLAND, 666 g.p.m., 150ft. head, 2850 r.p.m.
Two 35 h.p. Totally Enclosed SQUIRREL CAGE MOTORS by BRUCE PEEBLES, 2850 r.p.m., with Ellison starters.
Two 2½in. CENTRIFUGAL PUMPING SETS with 3 h.p. motors.
SURFACE CONDENSER by ALLEN, designed to handle approximately 23,000 lb. of steam/hr., 28½in. vacuum with extraction pump, air ejector and water circulating pump.
ALTERNATOR, 3125kVA., 400/440 volts, 3 phase, 50 cycles, 1000 r.p.m.
HOWDEN 5ft. 6in. diam. Induced DRAUGHT FAN with 66 h.p. motor and water cooled bearings.
DISTRIBUTION SWITCHBOARD by E.E.C., seventeen panels with instruments and circuit breakers, nine at 400 amps., four at 1000 amps., and three at 600 amps. Will sell separately.
ELECTRICAL EQUIPMENT, 400/440 volts, 3 phase, 50 cycles.
OTHER MISCELLANEOUS EQUIPMENT, MATERIAL AND PIPING also available at bargain prices.
Apply : Mr. Booth,

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SONS AND CO. LTD.
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Glasgow, S.3.
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600 H.P. TOTALLY ENCLOSED REDUCTION GEAR, by Turbine Gears, Ltd.; ratio 730/38·7 r.p.m. Unused.

F. BURRILL AND CO.,
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FOR IMMEDIATE DELIVERY

2 New 18in. bore HOPKINSON Cast Steel Parallel Slide Valves. One flanged to B.S.T. "H," the other to B.S.T. "J."
2 New 8in. bore HOPKINSON/FERRANTI Ditto, flanged to B.S.T. "S."
These Valves are being offered at very attractive prices.

G. E. SIMM (MACHINERY) LIMITED,
27, BROOMGROVE ROAD, SHEFFIELD, 10.
Tel.: Sheffield 64436. E8547 G

MASSEY 5-CWT PNEUMATIC POWER HAMMER. Overhanging type with slides, longest stroke 21in., number of automatic blows per minute, 140, anvil set at an angle to accommodate long bars, arranged direct motor drive, complete with anvil, centre to back 18in., size of bar worked 6in. square, weight about 6½ tons.—F. J. Edwards, Ltd., 359, Euston Road, London, N.W.1. EUSton 4681 and 41, Water Street, Birmingham, 3. CEN 7606–8. E8569 G

BERRY DOUBLE GEARED, DOUBLE ENDED, PUNCHING, SHEARING AND ANGLE CROPPING MACHINE for sale. Punches 1in. diameter hole through 1in. thick. Largest diameter hole 1¼in. Depth of gap 25¼in. Shears plates up to 1in. thick. Length of blades 17¼in. Depth of shear gap 25¼in. Crops angles up to 6in. by 6in. Arranged motor drive 400/3/50. Complete with 30 cwt. overhead gantry at each end and two tackle trolleys. Weight about 12½ tons.—F. J. Edwards, Ltd., 359, Euston Road, London, N.W.1. EUSton 4681 and 41, Water Street, Birmingham, 3. CEN 7606–8. E8570 G

FOR SALE

600

PUMPING SETS

Seven Diesel Engine-driven Pumping Sets by CROSSLEY/SULZER, 24,000 g.p.h. at 300ft. head.
2000 g.p.h. GWYNNE, 295ft. head, with 250 h.p. Brook motor, 400/440/3/50.
2000 g.p.h. W. H. ALLEN, 150ft. head, with 135 h.p. Laurence Scott motor, 400/3/50.
MANY OTHERS IN STOCK. WOULD WELCOME YOUR ENQUIRIES.
COMPRESSOR SETS
2500 c.f.m. BELLISS & MORCOM, 100 p.s.i. with 550 h.p. Crompton Parkinson motor, 3·3kV. or 400/440/3/50./
1550 c.f.m. BELLISS & MORCOM, 100 p.s.i. with 328 h.p. slipring motor, 400/3/50.

GEORGE COHEN,
SONS AND CO. LTD.
WOOD LANE, LONDON, W.12.
Telephone : Shepherds Bush 2070.
E206 G

SOAG

LATE TYPE
HEAVY DUTY
POWER PRESSES
IN STOCK

BLISS No. 668 Knuckle Joint, tonnage capacity 1500, platens 39in. by 42in., 3in. stroke, auto. feed, 39in. dia. rotary table, pneumatic cushions, h.p. motor 50.
WILKINS & MITCHELL 200-ton Double Sided, platens 31in. by 24in., 16in. stroke, 3in. adjustment, h.p. motor 45.
BLISS No. 4½ Three-Crank Double Action Cutting and Cupping Press, area of bolster 21in. by 26in., area of cutting slide face 12in. by 16in., area of drawing slide face 8in. by 10in., h.p. motor 10.
Inspection invited.
IT'S CHEAPER TO BUY NOW.
Full particulars on any of the above gladly sent on request.

SOAG MACHINE TOOLS, LTD.,
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'Phone : RELiance 7201.
'Grams : "Sotoolsag," London, S.E.11.
E213 G

NEW OVERHEAD CRANES

60-ton Goliath, by Clyde, 40ft. span, 5-ton auxiliary; cab control, 400/3/50.
40-ton Goliath, by Babcock and Wilcox, 40ft. span, 5-ton auxiliary; cab control, 400/3/50.
40-ton Adamson, standard cab control, 42ft 3in. span 400/3/50.
20-ton Vaughan, standard cab control, 42ft. 3in. span, 6-ton auxiliary; 400/3/50. EIGHT AVAILABLE.
10-ton Goliath, by Morris, 40ft. span, cab control, 22ft. lift, 400/3/50.
Surplus Unused Ministry Cranes, mainly still packed. Drawings on request. Inspection invited. Bargain prices about one-third of New.

FRED WATKINS (ENGINEERING)
LTD., COLEFORD, GLOS.
Tel.: Coleford 2271/2/3. E132 G

TWO BELLISS & MORCOM 2500 C.F.M. COMPRESSORS, 100 lb. w.p., 550 h.p. motors, 6600/3/50 supply. Used 4 years only. With Inter. and Aftercoolers, Receiver, Switchpanel. Available immediately.—FRED WATKINS (ENGINEERING), LTD., COLEFORD, GLOS. 'Phone : Coleford 2271/2/3. E139 G

FOR DISPOSAL, quantity of unused BALL AND ROLLER BEARINGS of Hoffman, S.K.F., R. and M., and Timken makes. These are obsolete, due to demolition of plant. Interested parties should write, Reference P/EB., Appleby-Frodingham Steel Company, Scunthorpe, Lincs, for details. Prepared to sell at very much below cost. E8509 G

COMPRESSORS FOR SALE

COMPRESSOR STATION comprising six 5,150 c.f.m. displacement COMPRESSORS by **Worthington, U.S.A.**, type DC1, horizontal 2-stage water cooled; speed 167 r.p.m. and designed for operating on air or gas; air pressure 170 p.s.i. Each driven by a 900 h.p. auto-synchronous motor, 3300 volts, 3 phase, 50 cycles, at unity power factor.
Six 1560 c.f.m. displacement COMPRESSORS by **Worthington, U.S.A.**, type DC2, horizontal single stage, water cooled; speed 231 r.p.m. and designed for operating on air or gas; air pressure 150 p.s.i. Each driven by a 500 h.p. auto-synchronous motor, 3300 volts, 3 phase, 50 cycles, at unity power factor.
Six 898 c.f.m. displacement COMPRESSORS by **Worthington, U.S.A.**, type DC3, horizontal single stage, single cylinder, water cooled; air pressure 65 p.s.i. Each driven by a 125 h.p. auto-synchronous motor, 3300 volts, 3 phase, 50 cycles, at unity power factor.
EACH MOTOR COMPLETE WITH STARTING EQUIPMENT
Further Details from :
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Mixing and Sifting Machines, Boiling and Mixing Pans, FYNA No. 7 GRINDING MILL, Cast iron and sectional Steel Tanks, Mixing and Evaporating Vats, Johnson 48 Plate Filter Press, KESTNER SPRAY DRYING UNIT, Filling Machines, Metal Containers, Maintenance Plant and Stores, Machine Spares, Electric Motors, Steel Piping, Trucks, Scales, Tables, Canteen Utensils, &c.

Leopold Farmer & Sons will sell the above BY AUCTION on the premises

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Catalogues at 6d. each of the Auctioneers, 46, Gresham Street, London, E.C.2. Tel: MONarch 3422 (8 lines). E8445 J

FOR SALE

600

MOBILE CRANES

JONES Super 22 Mobile Crane, lifting capacity 2 tons at 8ft. radius, powered by a Turner 2.V.95 Diesel engine, mounted on pneumatic-tyred chassis, fitted with 24ft. straight lattice jib.

JONES Super 40 Mobile Crane, lifting capacity 3 tons at 9ft. radius, powered by a Turner 2.V.95 Diesel engine, mounted on pneumatic-tyred chassis with restrictor type wheels, fitted with 24ft. channel jib.

JONES KL.44 Mobile Crane, lifting capacity 4 tons at 8ft. radius, powered by a Ruston 2.VSH Diesel engine, mounted on pneumatic-tyred chassis with restrictor type wheels, fitted with a 24ft. channel jib.

JONES KL.66 Mobile Crane, lifting capacity 6 tons at 9ft. radius, powered by a Perkins P.4 Diesel engine, mounted on pneumatic-tyred chassis with restrictor type wheels, 4-wheel differential drive, fitted with 30ft. lattice jib allowing a maximum lifting capacity of 4 tons.

GEORGE COHEN,

SONS AND CO. LTD.

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Tel.: Shepherds Bush 2070; and

STANNINGLEY, Nr. LEEDS.

Tel.: Pudsey 2241. E206 G

FOR SALE

10-ton Butters Hand Derrick Crane, 18ft. fixed radius.

3-ton Taylor Jumbo Hydraulic Crane, diesel driven.

5-ton Coles diesel-driven self-propelled Mobile Crane on pneumatics.

5-ton Morris Versatile diesel/elec. Mobile Crane on solid rubber tyres.

5-ton Smith Steam Loco. Crane, 4ft. 8½in. gauge, 35ft. jib, new 1949.

6-ton Rapier Super pet./elec. Mobile Crane on solid rubber tyres.

6-ton Rapier Standard pet./elec. Mobile Crane on solid rubber tyres.

Fordson Major diesel Tractor complete with Hornraulic shovel equipment.

¾ cu. yd. Rapier 410 diesel-driven Excavator with 4-purpose or dragline equipment.

¾ cu. yd. Rapier 423 diesel-driven Excavator with shovel or dragline equipment.

1 cu. yd. Rapier 440 diesel-driven Excavator with shovel or dragline equipment.

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E8453 G

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Thirty-fourth Sale

E R

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(4 miles from Kidderminster, 11 miles from Worcester)

Nock & Joseland are instructed to SELL BY AUCTION at the above Unit on

THURSDAY, 18th SEPTEMBER, 1958, at 11 a.m. prompt.

A Large Quantity of Valuable MISCELLANEOUS STORES including :—

CLOTHING AND EQUIPMENT
FOOTWEAR
PARACHUTES AND DINGHIES
CAMERAS, BROMIDE PAPER, &c.
RADIO AND ELECTRICAL EQUIPMENT
GENERAL STORES

VIEWING :

The Lots are on View at Hartlebury on Wednesday, 17th September, 1958, between the hours of 9 a.m. and 4 p.m., and on the morning of the Sale Day between the hours of 8 a.m. and 11 a.m.

Admission only on production of Catalogue, which will admit two persons on the View Day and one person on the Sale Day. The Secretary of State for Air reserves the right to refuse admission. Catalogues price ONE SHILLING EACH (Postal Orders not stamps) can be obtained from the Auctioneers—

NOCK & JOSELAND
Bank Buildings, Kidderminster.
(Tel.: 2053 and 4211.)

E8441 J

FOR SALE

NISSEN TYPE HUTS for sale. Prompt despatch of 16ft., 24ft. and 30ft. wide huts; also "Romney" Huts, 35ft. wide, and "Blister" Hangars, 86ft. 6in. and 91ft. wide. These buildings are in various lengths and comprise steel framework with galvanised corrugated steel sheeting.—Full details from Dept. 115, J. Thorn and Sons, Ltd., Brampton Road, Bexleyheath, Kent (Tel., Bexleyheath 305). E113 G

200KW MERCURY ARC RECTIFIER by Hewittic for 400 volts 3-phase supply and with 3-wire D.C. output 400 or 200 volts. Three-bulb unit.—THOMAS MITCHELL AND SONS, LIMITED, BOLTON. E8428 G

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E R

By Order of the Minister of Supply

GOVERNMENT SURPLUS STORES

SALES BY AUCTION

		Main Location	*Auctioneers*
September 16-17	**Miscellaneous stores,** including textiles, cordage, small tools, etc.	Central Ordnance Depot, **Didcot, Berks.**	**SIMMONS & SONS** (Dept. L), 12, Station Road, Reading, Berks. (Tel.: 54025.)
September 19	**Machine tools and miscellaneous stores,** including :—	Returned Stores Depot, **Reed Hall, Colchester.**	**FENN, WRIGHT & CO.** (Dept. L), 146, High Street, Colchester, Essex. (Tel.: 3171.)
	Jones & Shipman precision grinder, band wood sawing machine and other machine tools, carpenters, engineers and gardening tools, cable, scrap metal, cooking ranges, kitchen utensils, 800 1-quart vacuum jars, electric motors ¼ to 45 H.P., canvas clothing, webbing equipment, steel tubular scaffolding, builders materials, steel racking, clasp knives, etc.		
September 23-24	**Machine tools and miscellaneous stores,** including :—	M.O.S. Storage Depot, Harrogate Road, **Yeadon, Leeds.**	**DACRE, SON & HARTLEY** (Dept. L), Station Road, Otley, Yorks. (Tel.: 3321.)
	Hydraulic presses, multi-tool lathes, Pollard drilling machines, milling machines, Acme Gridley automatic, welding machines, tool cutters and grinders, "Tecalemit" 7-ton ramp and greasing unit, Lister auto trucks, power and gravity conveyors, circular saw benches, band saws, steel binning and racking, office tables, filing cabinets, cupboards, safes, etc.		
September 25–26	**Miscellaneous stores**	M.O.S. Storage Depot, **Rotherwas, Hereford.**	**RUSSELL, BALDWIN & BRIGHT, LTD.** (Dept. L), 20, King Street, Hereford. (Tel.: 4366.)
September 30 October 1	**Miscellaneous stores**	M.O.S. Storage Depot, **Ruddington Notts.**	**WALKER, WALTON & HANSON** (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 47271.)
October 3	**Miscellaneous stores**	Command Ordnance Depot, **Coypool, Marsh Mills, Plymouth.** (Sale at Kinterbury House.)	**WOOLLAND, SON & MANICO** (Dept. L), Kinterbury House, St. Andrews Cross, Plymouth. (Tel.: 65356.)
October 7	**Miscellaneous stores**	M.O.S. Storage Depot, Lily Lane, **Byley, Middlewich, Cheshire.** (Sale at New Islington Public Hall, Ancoats, Manchester.)	**J. H. NORRIS & SON** (Dept. L), 9, Albert Square, Manchester, 2. (Tel.: Blackfriars 8373.)
October 14-15	**Vehicles and miscellaneous stores**	Central Ordnance Depot, **Bicester, Oxon.**	**MIDLAND MARTS, LTD.** (Dept. L), Market Square, Bicester, Oxon. (Tel.: 73.)

Catalogues for the above auction sales, 1s. 0d. each (P.O.'s only), obtainable *only* from the auctioneers shown above.

SALES BY TENDER

(1) One internal 300 line private automatic telephone installation with equipment and 237 telephone instruments and certain spares. Located at Yeadon, near Leeds.

(2) Large quantities of crankcase and gear oils in jerricans, grease, fluid alcohol, aviation turbine fuel, furnace fuel (medium), glycerine, etc. Lying at various locations.

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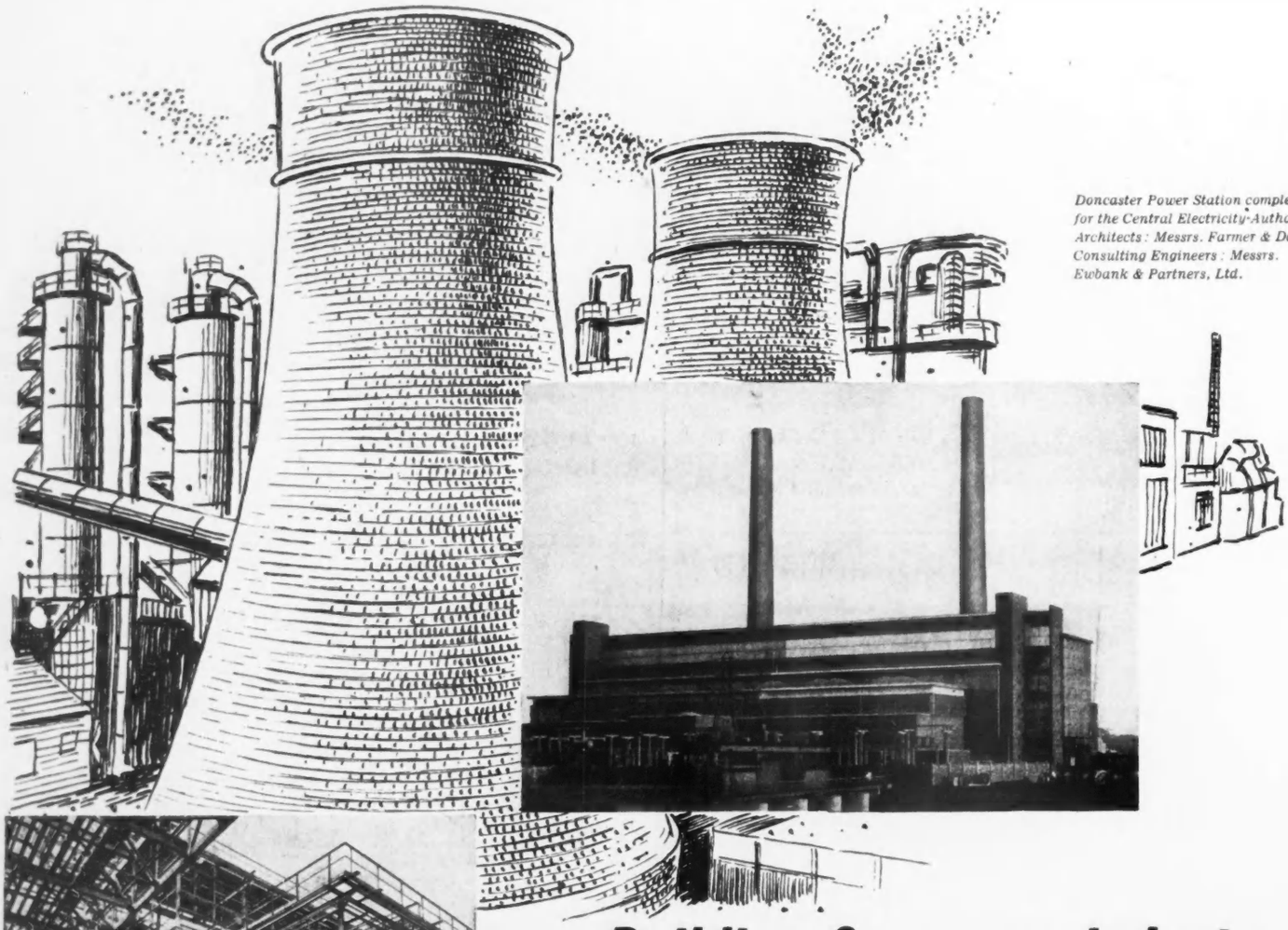

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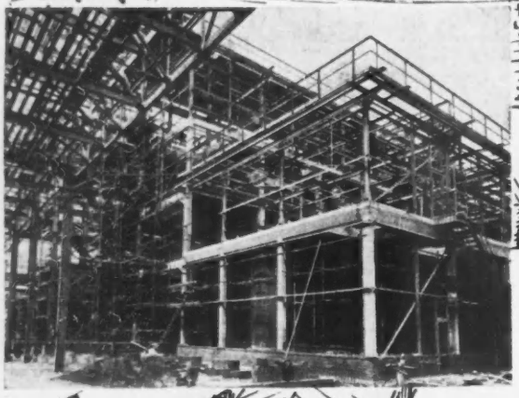

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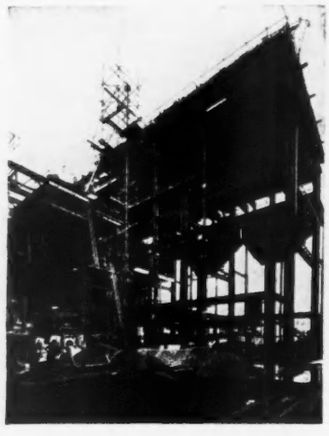

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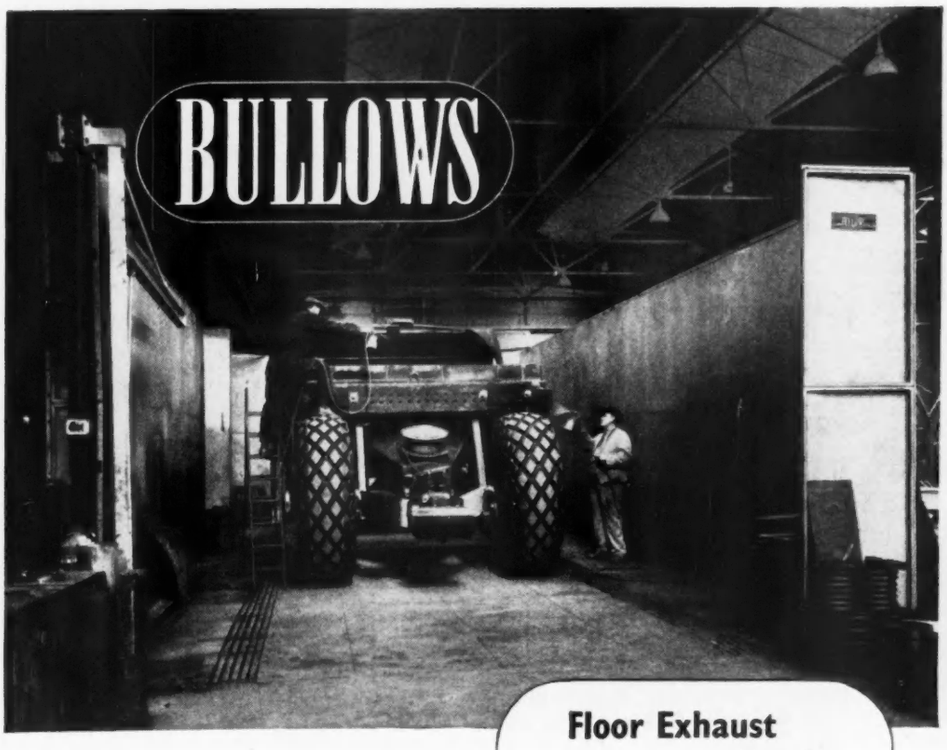

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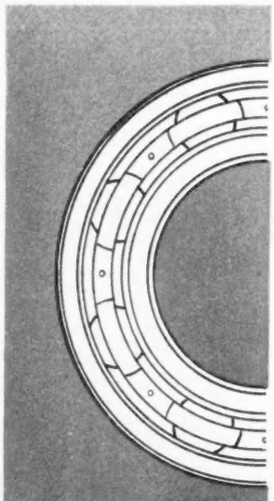

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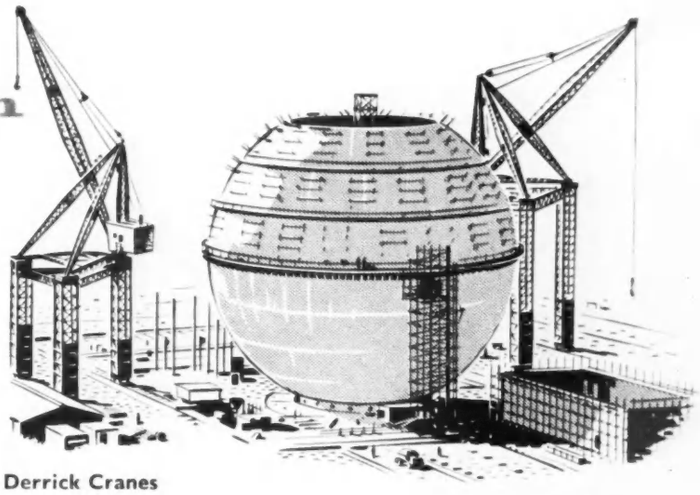

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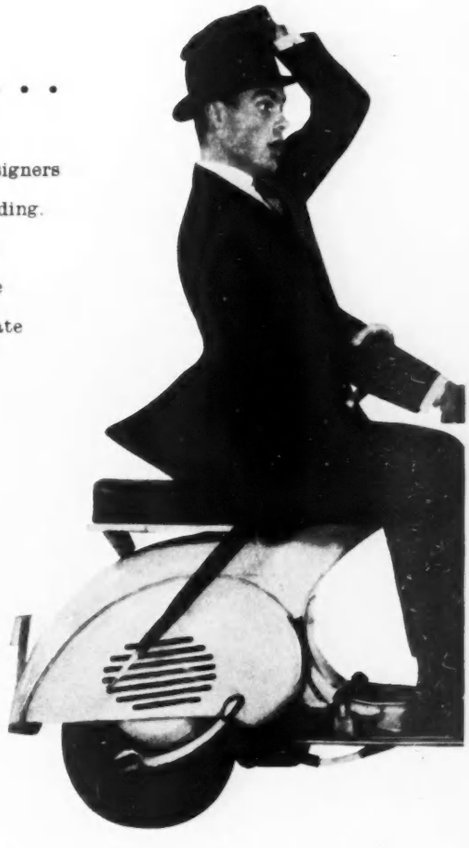

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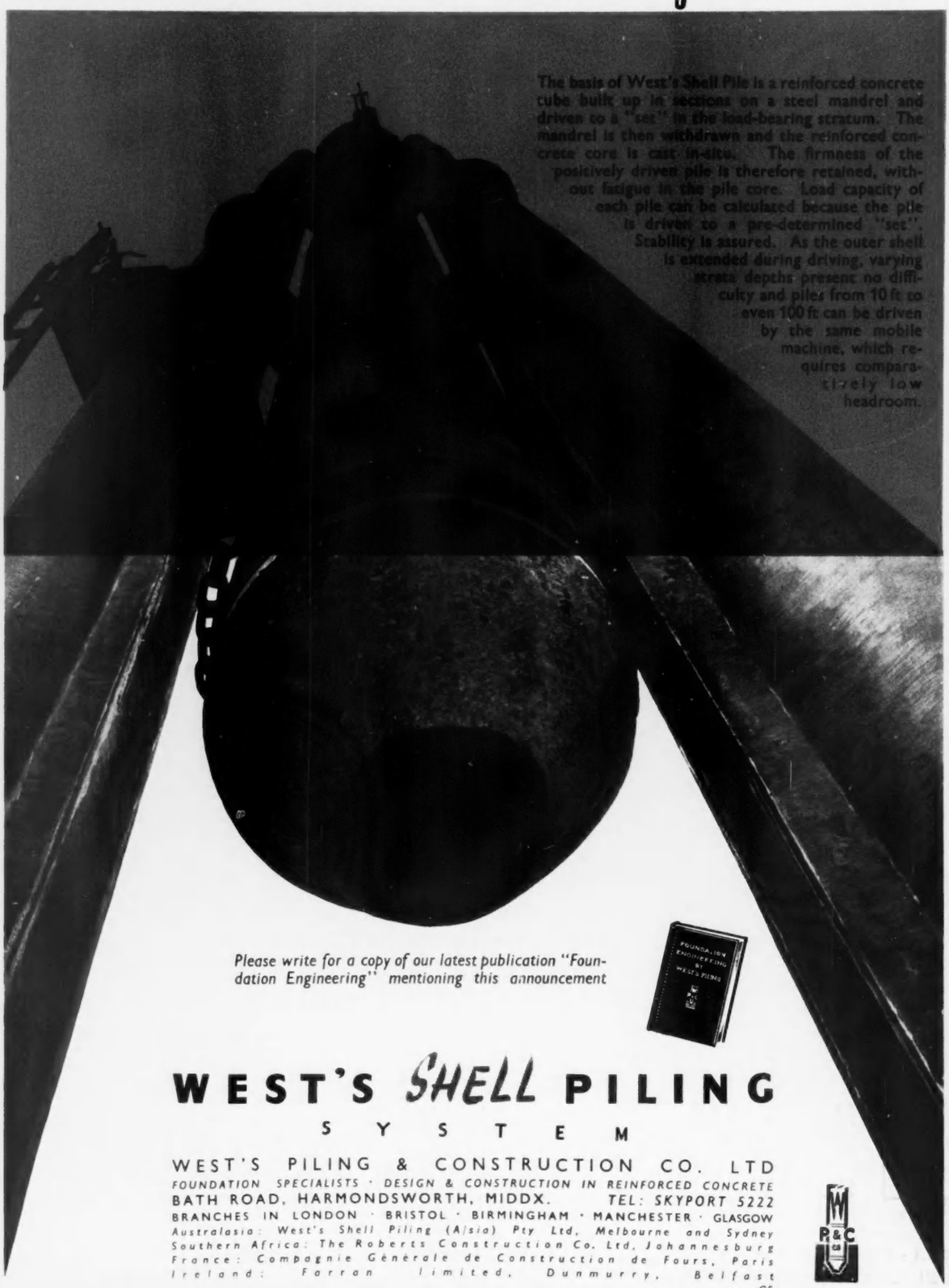

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